A DISCUSSION OF THE RELATIONSHIP
BETWEEN THE
TIDAL INFLUENCE OF THE MOON
AND THE PERIODICAL FLOW
OF AN OIL WELL

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P R E F A C E.

The observations included in this paper were obtained during the fall of 1917 while the writer was employed in the Engineering Research Department of the Empire Gas and Fuel Company. The material was obtained in the ordinary course of duty and without regard to the main theory or idea advanced in this paper. Attempts have since been made to obtain more data tending to substantiate this theory, but unfavorable conditions have thus far precluded further observations chiefly because very few of the wells owned by the above Company have been found which flowed naturally, either periodically or steadily for any appreciable length of time. It is hoped that opportunities will be offered in the future whereby additional investigations may be conducted.

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HISTORY OF THE SHRIVER NO. 3

OIL WELL.

HISTORY OF THE SHRIVER NO. 3 OIL WELL.

In the first month or so of its existence the Empire oil well known as Shriver No. 3 exhibited some rather peculiar characteristics in the matter of flowing periodically. In this paper a short history of the well is given, the periodical flows are described, and certain interesting facts are set forth which may have been influential in causing the periodical flows. The well was observed for nearly one month to flow naturally about twice a day, the periods being roughly about eleven hours apart and showing a decided harmonic relationship to the times of the maximum tidal influence of the moon and sun.

The Shriver No. 3 oil well is owned by the Empire Gas and Fuel Company of Kansas and is located in the ElDorado field, Butler County, near Towanda, Kansas, in the north-west quarter of Section 14, Township 26, Range 4, 200 feet from the north line and 192 feet from the east line of the quarter-section. The well is situated close to the noted "Trapshooters" lease which, together with the well known Shumway lease, lies in the section immediately north of the Shriver farm.

A short geological discussion of this region is included in this paper as Appendix D. This discussion was prepared by Mr. A. W. McCoy, head of the Sub-Surface branch of the Geological Department of the Empire Companies.

Drilling at the Shriver No. 3 commenced August 14, 1917, and was completed on October 3, 1917, to a depth of 2368 feet. Later measurements seem to show that the total depth was only 2361 feet. The Stapleton sand was entered to a depth of 35 feet. Table No. 1 attached hereto shows the driller's log. At 2010 feet four bailers of water and oil were taken out; at 2030 feet, 20 bailers of water; at 2086 feet the hole stood full of water; at 2332 feet a limestone shell was encountered and 6-5/8 inch casing was set upon this shell. A showing of oil was obtained at 2333 feet, and at 2345 feet the hole stood full of oil. At 2358 feet the well flowed at the rate of 65 barrels per hour; at

2363 feet at the rate of 85 barrels per hour, and at 2368 feet the "big pay" was encountered, showing 23,000 barrels per day during a nine minute test. Storage and pipe-line pumping facilities were lacking, so the well was shut in. In the afternoon of the same day, (October 5th, 1917) the well was opened, and a flow gauged at 16,000 barrels per day resulted. Then the well was again shut in; on the next day, October 6th, the well was opened, showing no pressure, while a very small flow resulted. The bailer was run, and water to a depth of 200 feet was found in the bottom of the hole. (This part of the Log is at variance with information received by the writer from drillers working on the lease and comment is made thereon in the following pages). Then 3 inch tubing was lowered inside the casing and the well was put on the pump and remained so until about Nov. 1st, 1917. On October 9th, 1917, Shriver No. 3 was pumping about 10 percent of oil through the 3 inch tubing. By this is meant that of the total amount of liquid pumped from the well, 90 percent was salt water and 10 percent was oil. On October 11th, the well showed about 25 percent of oil on the pump. On October 20th the pumped oil dropped to about 5 percent, and on the 22nd of October only salt water was obtained by the pump. The well did not flow naturally during this time. On October 25th 500 feet of 1 inch air line was lowered thru the top of the casing head, beside the 3 inch tubing, and 140 pounds air pressure was put on the 1 inch line; a flow of about 30 barrels of oil resulted, then only salt water was obtained. It of course should be generally understood that this "air line" was open at the bottom. The air was discharged into the space between the tubing and the casing and rose, pushing out of the top of the casing the liquid which stood above the lower end of the 1 inch air line. Later in the same day (October 25th, 1917) the well was again put on the pump, obtaining only water, while a pressure of 130 pounds on the 1 inch air line resulted in a small flow of good oil between the 6-5/8 inch casing and the 3 inch tubing. About November 1st the pump was removed from the 3 inch tubing, the 1 inch air line was taken out, and a packer was set on the 3 inch tubing at a depth of 2355 feet, 6 feet off bottom. A "packer" is a member, generally made of rubber, used in separating or "packing off" one vertical portion of the well from another vertical portion of the well. The words "plugging off" describe the same accomplishment. The depth of 2361 feet was determined by steel line, while the depth of 2368 feet mentioned above was cable measurement. On November 2nd, from 11:00 A.M. until 2:30 P.M. the Mudding Department pumped in about 170 barrels of mud, thru the 3 inch tubing and into the sand below the packer.

In this paper the word "mud" is used to designate mud-laden fluid of about 1.20 specific gravity (water being 1.00). The assumption as to specific gravity is made by the writer, since no official records have been found regarding this item.

It is perhaps worth while to note here the behavior of the nearest flowing well owned by the Empire Company, the Cardy No. 8. This well is located some 900 feet north-west of the Shriver No. 3. Cardy No. 8 continued flowing naturally during the initial high flow of Shriver No. 3. The amount is not known to the writer. When Shriver No. 3 stopped flowing after the second test Cardy No. 8 also stopped. When Shriver No. 3 was put on the pump, Cardy No. 8 began producing again, but this time on the swab. A "swab" is simply a type of plunger, carrying a check valve attached to the "stem" at the end of the drilling cable, by means of which the oil may be pumped out of the well, the casing forming the pump cylinder.

The above information was obtained from the drillers' log, and from a letter to Mr. McCoy of the Bartlesville Geological Department, written by Mr. Parker, resident ElDorado geologist. The following history of the well was obtained from personal observation, from talks with the men in charge, and from the records obtained by means of a recording pressure gauge.

While it is not the purpose of this paper to discuss the reasons for the non-appearance of the big flow after shutting in the well, some comment thereon may be of interest. According to information received from drillers working on the Shriver and on adjacent leases, the Stapleton is a fine, close-grained sand. As will be seen later, it does not seem to have been so close-grained as to prohibit the idea of a communication between this well and others located nearby. It is known that the capillary attraction of water is nearly one and one-half times that of oil, and therefore water will flow from a coarse into a finer sand with greater certainty and speed than will oil. Also, granting water underlying oil in the same strata, water will fill a void with greater speed than oil. This then may account for the finding of water in the hole after the large initial flow. At the same time it is possible to reason that if the well had not been shut in a continued flow of oil might have been obtained, although perhaps diminishing appreciably in quantity from day to day. The writer was told that two other wells in this pool behaved somewhat similarly when shut in. One of these wells was on the Cardy farm. It was drilled into the sand with an initial high flow; was shut in for a day or so, and when opened refused to produce anything like the quantity shown in the first flow. The discharge pipe was left open and later the well began to pick up and gradually reached a point where it produced oil naturally by an amount equal to about half the initial flow. The other well mentioned by the writer's informant was on the lease west of the Cardy (and north of the Shriver) and behaved about the same as the Cardy well. It seems that once started, the flow will continue, but if artificially stopped, the crevices opened up by the first big flow become stopped up; therefore the natural inference is that the well should be permitted to flow at all costs.

It may be of interest to mention here the essential part of a conversation the writer had with a driller working on Shriver No. 5, the next location west of Shriver No. 3. This item is in regard to the finding of 200 feet of water in the bottom of the hole after the failure of the "big flow" to materialize. The information received was to the effect that after the big flow of Shriver No. 3 had dwindled to zero, drilling was resumed in order to stimulate this flow again, that a hard limestone cap rock was encountered below the oil sand, and that immediately below this cap-stone a water sand was struck; this water sand was subsequently packed off by means of the 3 inch tubing and packer. The essence of the information gained from the driller is to the effect that the oil sand lies immediately over a heavy water sand, separated by a thin cap rock. The records as given above do not mention this cap-stone, but do show that it became necessary to pack off a water sand. Shriver No. 5 was drilled into the Stapleton sand shortly after the writer reached the field and showed a nice flow of oil on the swab. Instructions were given to continue drilling, which procedure was followed. This driller told the writer that the same thin cap-stone was encountered and that drilling was continued 3 feet into the water sand. It is a fact that shortly afterwards it became necessary to "plug off" Shriver No. 5. In the writer's opinion it is fairly safe to assume a distinct separation between the heavy water sand and the oil sand immediately above. This assumption is sustained by the fact that the application of fairly high pressures upon the water sand failed to force the mud into the oil sand. It will be noted that no reference is made to this cap-stone and water sand in the drilling log attached hereto. It is not safe to say that the seal is absolutely without a break; in fact circumstances seem to show that there is a connection between the two sands, possibly at some distance from the well, and then only thru openings, crevices, or spaces which are relatively small. Of course the assumption of a seal between the two sands need not prohibit the finding of water in the oil sand proper; it seems to be absolutely certain that there is water in this oil sand, below the oil. It is the writer's information that the almost universal rule in oil and gas strata is that water underlies all oil, while gas, if present lies above the oil.

After 170 barrels of mud had been pumped into the tubing it was found impossible to pump in any more; in an effort to do so the pressure on the mud was increased to about 400 pounds. This pressure was indicated by a recording pressure gauge, at the top of the 3 inch tubing. The pressure was maintained by means of a steam-driven duplex "mud-hog" or mudding pump. It was now found that a natural periodical flow of oil resulted, giving about two flows every 24 hours. This flow occurred between the 3 inch tubing and the 6-5/8 inch casing. At the time of a flow the mud pressure was self sustaining, even rising 75 to 150 pounds. In the intervals between flows it was necessary to pump up the mud pressure about every hour in order to maintain 400 pounds. One or two strokes of the mud pump was generally sufficient to raise the pressure 100 pounds. At 1:00 P.M. on November 9, 1917, Mr. E. O. Hickstein and the writer began watching the well, taking hourly readings of pressure, quantity of oil flowing, etc. These observations are included in tabular form in this paper (Table No. 2). About this time the "mud-hog" was disconnected and thereafter pressure was maintained by means of a small hand-driven hydraulic test pump. On November 14th a 1 inch air line 400 feet long was run into the hole, inside the 6-5/8 inch casing and outside the 3 inch tubing. In doing this it was necessary to relieve the mud pressure on the 3 inch tubing and to remove the anchors from the tubing. When removing the anchors the top of the 3 inch tubing rose some 3 or 4 inches, while the level of the mud in the tubing dropped several feet. Some hours later 200 feet more of 1 inch air line was placed in the well, making a total of 600 feet. On November 16th the pressure was again placed on the mud, and 400 to 900 pounds we maintained until November 21st when the pump broke. On November 20th at 12:30 P.M. an air pressure of 225 pounds was placed on the 1 inch air line; a good flow of oil soon came, in an hour the flow was intermittent, and in 12 hours no more oil was obtained. The next day at noon the air was shut off. According to the writer's information the well did not again flow naturally. The men in charge decided to pull the 3 inch tubing, remove the packer, and put the well on the pump again. Considerable trouble ensued during the next several months, due to water, and various steps were taken in an effort to remedy this difficulty. Since the writer's observation of this well ceased about the same time the natural flows of oil stopped, and since this paper is concerned primarily with the natural-flow phenomena, the latter history of the well is omitted from this paper.

It may be well to note here that the men in charge of the well told the writer that no gas was encountered at any time; that neither the first heavy flow, nor any subsequent flows, was accompanied by gas, and that therefore the oil flow could not have been caused by gas pressure. During the time the writer was at the well a strong hydrogen-sulfide smell could be detected when standing on the derrick floor, but the quantity of gas issuing from the well must have been quite small. There was certainly no perceptible flow of gas, either from the joints in the casing head, nor from the 6 inch flow line running from the top of the casing to the flow tank.

A brief analysis is inserted here regarding the conditions obtaining at the bottom of the well upon the application of an artificial pressure at the top of the mud column contained in the 3 inch tubing. For the sake of the argument let it be granted that the oil and water sands are separated by an impervious seal. Below this seal or cap-stone the mud pressure is transmitted in all directions from the source of pressure on top of the ground. Considering the portion of the cap-stone in the immediate vicinity of the well the pressure upward on the cap-stone may be regarded as the resultant of two hydrostatic pressures: the mud pressure upwards, and the oil pressure downwards. The mud has been assumed to have a specific gravity of 1.20, then the upward pressure on the cap-stone due to the mud is (2360)(.43) or 1217.76 pounds per square inch. The oil from Shriver No. 3 was 32 degrees Baume, corresponding to a specific gravity of 0.864. Therefore the downward pressure of the oil upon the cap-stone, assuming the well full of oil and air a practically static condition, was (2360)(.43)(0.864) or 876.79 pounds per square inch. Hence the resultant pressure, directed upwards on the cap-stone, was 1217.76 less 876.79 or 341 pounds per square inch. Apply 400 pounds artificial pressure to the mud by means of the pump, and this resultant upward pressure would be 741 pounds per square inch. The pressure on the cap-stone in the general region surrounding the well may be calculated in another way. This may be done by figuring the weight of the material (sand, limestone, shale, etc.) resting upon the cap-stone. Assuming an average specific gravity of 2.5 for this material; the downward pressure is (2360)(0.43) or 2537 pounds per square inch. Assuming weights per cubic foot for the various strata (from Kent), multiplying by the depth of the stratum, taking the total and dividing by 144, the downward pressure is found to be 2500 pounds per square inch. (The complete calculation is attached hereto as Table No. 8). This pressure is resisted by an equal upward pressure, since the cap-stone is in a practically static condition. Then the resultant pressure upward on the cap-stone is simply the weight of the column of mud, plus the artificial 400 pound pump pressure, or 741 pounds per square inch, as shown above.

During the interval the Shriver No. 3 was under the writer's observation a number of oil samples were taken and the quantities of water, sediment, etc. contained therein were determined by centrifuge tests. The results of the tests are the basis of the statement previously given to the effect that there was no immediate connection between the water and oil sand, because the samples showed no "mud" content. If these samples had been taken systematically the results obtained therefrom might have been of considerable assistance in explaining some of the features discussed in this paper; however, the samples were taken irregularily and spasmodically, and show no items of interest, other than the absence of "mud".

A brief resume of the history of Shriver No. 3 shows that when 3 inch tubing was placed inside the 6-5/8 inch casing, was packed off 6 feet from the bottom, was filled with mud, (thus also filling the hole below the packer), and an artificial 400 pound pressure was maintained thereon, a natural periodical twice-a-day flow of oil resulted from the casing, accompanied by a natural increase in the pressure on the mud. These flows lasted 3 to 6 hours, and totaled about 170 barrels to the flow. The flows were roughly 11 hours apart.

In an effort to locate the cause of this periodical flow the writer thought of the tidal influence of the moon, as manifested by the ocean tides, and the object of this paper is to show the extent of the investigations thus far conducted which tend to prove or disprove the "tidal" or "lunar attraction" theory regarding the cause of the flows.

A short discussion on tides is included in this paper as Appendix A which may be referred to for an explanation of certain terms used in the following pages.

EXPLANATION

OF

CURVES.

EXPLANATION OF CURVES.

In the accompanying curves the time of passage of the moon over the meridian (moon's culmination) has been contrasted graphically with the known time of flow of Shriver No. 3. This in itself ought to prove or disprove the harmonious relationship supposed to exist between the flow and the tidal influence of the moon. As a further check a theoretical ocean tide has been calculated and plotted on the same sheet, giving the probable times of high and low tides at ElDorado. Two such "tide" curves have been plotted. The first assumes the tidal force acting along a parallel of latitude. In calculating this tide it became necessary to select two points, one on the Atlantic coast and the other on the Pacific coast, so chosen that they lie on the same parallel with ElDorado. Old Point Comfort, Virginia, and San Francisco, California, meet these requirements with reasonable accuracy. The U. S. Tide Tables give the times of tides (and heights of water) on the Virginia coast based upon the 75th degree of longitude, West. The time for San Francisco is based upon the 120th degree of longitude, West. ElDorado lies fairly close to the 97th meridian. Therefore the time chosen as being indicative of the tide's arrival at ElDorado has been the mean of the times given for Virginia and California. An example will make this clear. On November 1st, 1917, high tide arrived in Virginia at 10:30 A.M.; the corresponding high tide in California arrived at 12:00 Noon; therefore we may conclude that it reached Kansas about 11:00 A.M. The entire figures for the month of November are given in Table No. 3 attached hereto.

The second "tidal" curve is based upon the assumption that the proper time for ElDorado could be obtained by taking points on the Atlantic and Pacific coasts having approximately the same height of tide. Sandy Hook, New Jersey, and San Diego, California, come nearest to this requirement, and these two points lie reasonably close to the same Great Circle that passes thru ElDorado. The figures for this curve are shown in Table No. 4 attached hereto. It will be noted that there is a fairly constant difference between the two "tide times" thus calculated.

The writer has not yet obtained sufficient data to say whether or not the maximum flow from the well should occur simultaneously with the moon's culmination, and thus conform to the action of the solid earth under like influences, or whether the dynamic theory obtains, under which the maximum flows would tend to harmonize more nearly with a calculated ocean tide; therefore the curves are submitted as they were originally drawn up.

With this explanation in mind let us refer to the curve sheets where all these various times have been noted. The following factors appear on the curves:

(1) "Parallel" Tide.
(2) "Great Circle" Tide.
(3) Description of flow.
(4) Moon's culmination.
(5) Sun's culmination.
(6) Maintenance of mud pressure.
(7) Pressure of mud in tubing.
(8) Quantity of oil flowing.

The curve has the form of an ordinary "production" curve, wherein "times" in days and hours have been plotted as abscissas, or distances along the greater dimension of the co-ordinate paper, while the various other quantities have been plotted as ordinates, or vertical distances, along the shorter side of the sheet.

The method of obtaining the data from which the two "tide" curves have been plotted has already been explained. The "Parallel" tide is shown by a full ziz-zag line at the top of the sheet. The high points indicate the expected arrival of a "high" tide, while the low points indicate the time of "low" tide. The "Great Circle" tide is shown by means of a dotted zig-zag line closely following the "parallel" tide. At each "high" and "low" point are two quantities, given in figures. The quantities above the points show the heighths of water on the Atlantic coast, while the figures below the points show the heighths of water on the Pacific coast. Take for instance Curve Sheet No. 1 showing the data for Nov. 4th, 1917. The first "Great Circle" high tide occurs at about 11:20 A.M. The heighth of water at Sandy Hook was 4.9 feet, while at San Diego it was 5.0 feet. The following "low" tide for this curve occurs at about 5:30 P.M., and the height of water on the Atlantic coast was 0.3 feet, while on the Pacific coast it was 0.6 feet. The first "Parallel" high tide occurs at about 1:30 P.M.; heighth of water at Old Point Comfort was 2.5 feet and at San Francisco was 5.0 feet. In following these figures through it will be seen that a rather peculiar condition occurs where in at some "low" tides on the Pacific coast the water does not fall anywhere near as low as it does at the preceding or next succeeding "low" tide. These tides have been called "Half-tides" in this paper in order to distinguish them from the ordinary "low" tides. The heights given in the curves are based upon various levels at the respective stations, determined by the Government, and on these curves serve simply to indicate the probable tendencies of these theoretical "tides" at ElDorado. It should be noted that in calculating these "tide" curves only the time of "high" tide was considered. In obtaining the time of "low" tide it was deemed sufficient to locate the "low" tide exactly mid-way between adjacent "high" tides. This was done on the curve by the use of a pair of drafting dividers, or compasses. It is entirely possible that this "low" tide time, as shown on the curve, may not quite check a calculated "low" tide, but the difference can not possibly amount to more than an hour at the most, which possible inaccuracy in no way affects the general results shown by the curve.

During the first six days shown in the curves, no record was kept of the quantity of oil which flowed from the Shriver No. 3. However during this period the drillers kept a rough sort of "log" or hourly record wherein were noted a description of the flow, the time at which it occurred, and the mud pressure. The last item was checked by a recording pressure gauge from which source has also been obtained the information concerning the natural rise and fall of the mud pressure. During the period the well was under the writer's observation, the drillers were instructed to continue the entrees in this "log". It was found that their "description" of the flow coincided nicely with the results obtained by actually measuring the oil produced in the flows. The drillers described the flow by writing words corresponding to "Best", "Strong", "Light", and "No Flow". The "No Flow" condition was in reality a very light flow, amounting to about one-half barrel, 42 gallons to the barrel, per hour. Up to the time when the air-lift was installed the well never actually ceased flowing altogether. In the periods between flows the stream of oil issuing from the well dwindled possibly to the size of a lead pencil. From this it will be seen that the "Description of Flow" affords the most complete consecutive record of the well's performance. This data has been plotted as a full line, the differences in flow being shown by vertical steps, or as ordinates. In conjunction with the "culmination" curves explained hereinafter, particular attention is called to this "Description of Flow" curve, since these two curves seem to afford the simplest and best means of showing the harmonic relationship which appears to exist between the tidal influence and the periods of flow. Table No. 2 contains the "Description of Flow" data.

The next item shown on the curves is the culmination of the moon, or passage of that body over the meridian, and the time of rising and setting. These items are shown by means of a full zig-zag line, the upper points thereon being the passage across the meridian, while the lower points show the "rising" and "setting" times. The actual time of rising and setting have been taken from the Tide Tables, and are those given for Washington, D. C. This time is based upon the 75th degree of longitude, West, which roughly is local time for Washington; and since Washington and Kansas lie practically upon the same parallel of latitude, local time for Washington is assumed (for the moon) as true local time for Kansas. This curve must contain small discrepancies, from two courses. In the first place, Washington and ElDorado do not lie exactly upon the same parallel, but the difference is too small to seriously affect the general results shown on the curve. In the second place, only the times of rising and setting of the moon was considered, the culmination being obtained by the use of the dividers. The figures from which the curve is plotted are given in Table No. 5 attached hereto. Some months after these curves were prepared a table was received from Mr. W. G. Eichelberger, Professor of Mathematics, U. S. Naval Observatory, Washington, D. C., giving the true and accurate time of the moon's meridian passage at ElDorado. These figures are included herewith as Table No. 6. In comparing this table with the curve it will be seen that the passage as shown on the curve averages about an hour slow. As stated above this difference does not affect the general harmonic relationship between the essential factors as shown on the curves.

The sun's time of rising and setting and meridian passage are next shown on the curve by means of a dotted zig-zag line closely following the similar curve for the moon. The figures were obtained from the Tide Tables, are shown in Table No. 7 attached hereto, and are for 38 degrees north latitude. The culminations were obtained by means of the dividers. This curve, with that of the moon, is useful in showing when "spring" and "neap" tides might be expected; the "spring" or full tide occurs at 11:40 A.M., November 14th, while the "neap" or ~~low~~ tides, occur some where near November 20th.

The next item shown on the curve records the data regarding the maintenance of mud pressure. The workment at the well were instructed to maintain a given pressure, say 400 pounds, on the mud in the 3 inch tubing. They visited the well every hour, recorded the pressure as shown on the gauge, which we will say was 315 pounds, as shown at 10:00 P.M. on November 4th. Immediately afterwards the pressure was increased to about 400 pounds by means of the "mud-hog" pump or by means of the hydraulic test pump. At the end of the next hour the pressure would have fallen to say 300 pounds, and was again increased to 400 pounds. But when the flows of oil started it was found unnecessary to use the pump to maintain the specified pressure on the mud since the pressure usually rose automatically or was self-maintaining, during the period of "best" and "strong" flows. This phenomenom has been shown by a series of full straight horizontal lines, the higher portions thereof showing that the pump was not needed, or that the pressure was "natural" or self-sustaining, while the lower portions show that the pump was used about every hour. The information shown by means of this curve was gained from the charts obtained from the recording pressure gauge attached to the 3 inch tubing and the tabulated data is given in Table No. 2. The essential thing shown by this curve is the point mentioned above: that during the period of flows the mud pressure was self-sustaining, or even rose naturally from 75 to 150 pounds. This coincidence in pressure-increase and maximum flow is very graphically shown further on in the curves at the time when the top of the 3 inch tubing was uncovered, the mud being exposed to atmospheric pressure, the artificial pressure on the tubing having been previously reduced to zero (gauge). This condition is shown on Curve Sheet No. 7, starting at 9:00 P.M. November 15th. Lacking the pressure readings, the actual height of the top of the mud in the 3 inch tubing was measured each hour, and the curves show in an excellent fashion how this mud level rose and fell in unision with the "Best" and "strong" flows.

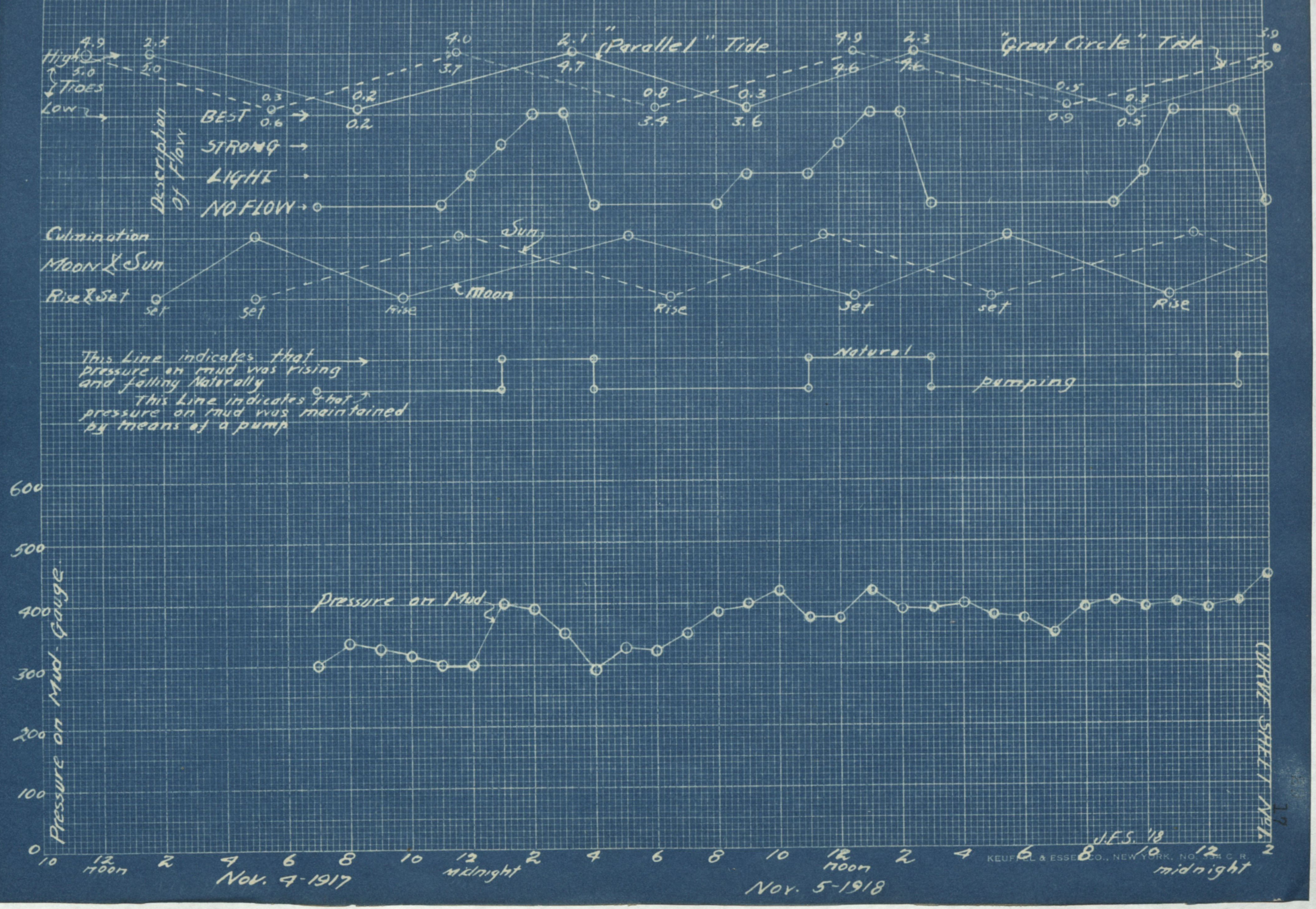
The actual pressure on the mud at every hour is next shown by means of a full line. This data has been partially explained in the foregoing paragraphs, and the figures are shown in Table No. 2. If this curve were rigidly accurate and plotted exactly according to the facts, two pressures would be shown at each hour; the first being read before "pumping up" the mud pressure, and the second being that to which the mud pressure was increased. Then the curve would be vertical exactly on the hour, and gradually slope to the lower pressure shown at the next hour, excepting, of course during the "natural" periods previously discussed. However, the "high" pressure, or that to which the mud pressure was increased at each hour follows the same average figure, say 400 pounds, for many consecutive hours, therefore it was thought that the facts could be sufficiently presented in readable shape by the curves as shown, and the second or "high" pressure was omitted from the curves. It will be seen that the record given by the "pumping" line, and that given by the "pressure" line do not always check while there are other places, as for instance Curve Sheet No. 3, starting at 12:00 noon, November 8th., where the two records check nicely. These discrepancies may be partially explained in various ways. One is that the clock on the recording gauge did not check with the true time of day by something like half an hour. By this is meant that in the daily process of changing the charts on this gauge the men in charge managed to set the starting point a half hour late. This condition was remedied shortly after the installation of readings tending to show the hourly quantities of oil flowing from the well. A second explanation may lie in the fact that it is quite possible that the data covering pressures as recorded in the "Log" is not always accurate.

Beginning November 9th a series of readings were taken hourly whereby an attempt was made to obtain the quantity of oil flowing per hour. This quantity has been shown by a dotted line, the quantity, in barrels per hour, being plotted vertically, as ordinates. The data is shown in Table No. 2. The oil flowed from the well direct to a "flow" tank, from which it was pumped to a larger "storage" tank. Hourly gaugings were taken on both tanks. The men employed as gaugers and pumpers used the minimum of intelligence necessary to maintain life on a Butler County oil lease, and in consequence the gaugings were inaccurate, and in many cases the oil from the Shriver No. 3 flow tank, instead of going to the prescribed storage tank, often went to a field-boiler fuel tank, or to another storage tank, or on to the ground. From observation it is positively known that in practically all cases the flow of oil from the Shriver No. 3 gradually increased from "No Flow" to a "Strong" or "Best" flow, and after flowing strong for an average of two hours, usually fell within a relatively short period, as compared with the time of increasing flow, to a "No Flow" basis. In hardly a case was a divergence from this procedure noted, whereas considerable discrepancies will be seen on the chart, such as are shown on Curve Sheet No. 4, at 5:00 P.M. on November 9th, and again on Curve Sheet No. 8, at 5:00 A.M. on November 16th, therefore we conclude that the irregular shape of the "quantity per hour" curve at those and similar points is due to inaccuracy in gauging, or to blunders in pumping the oil from the flow tank.

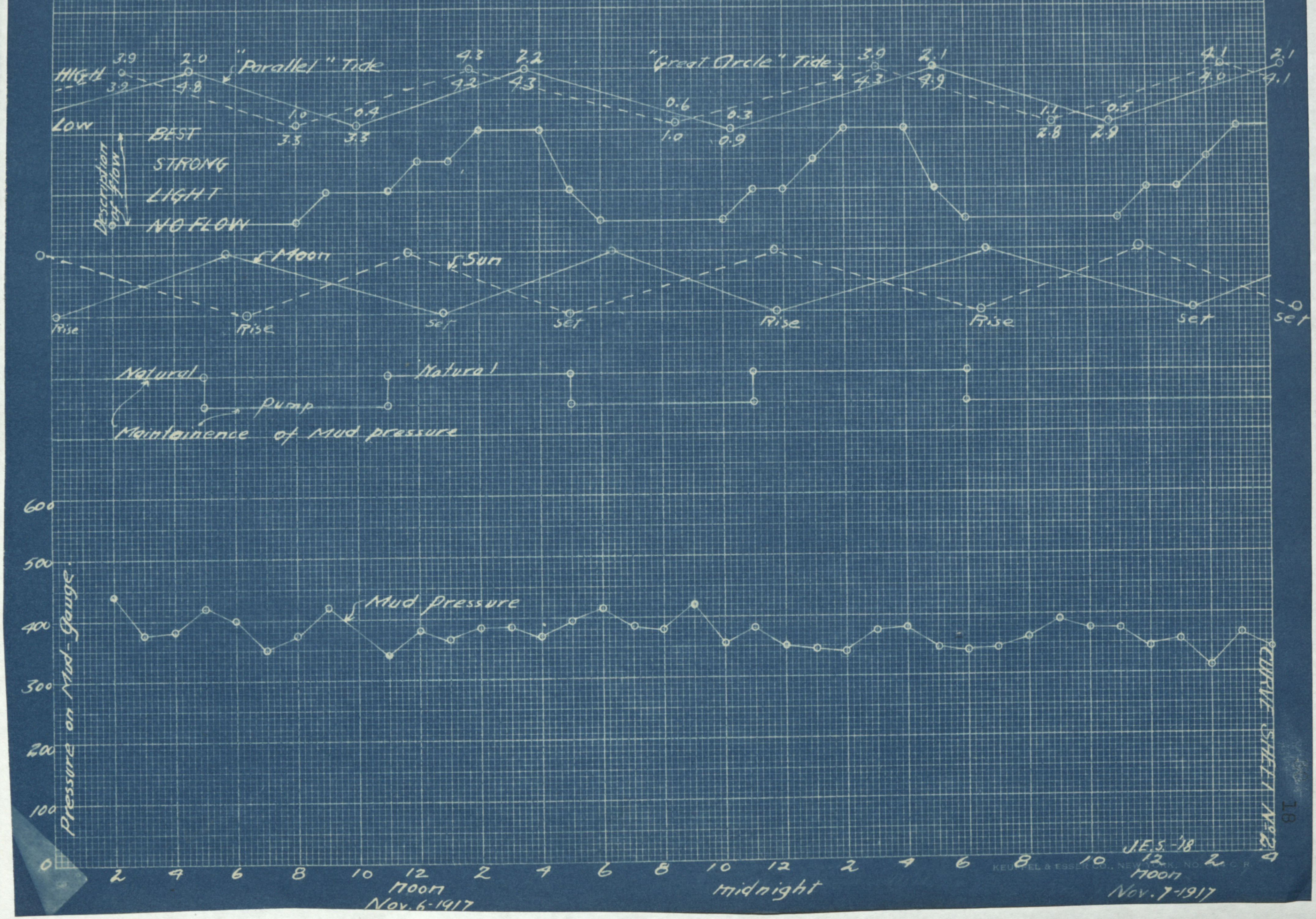
During the first eight days shown on the curves, their periodical flow seems to harmonize nicely with the moon's culmination and with the calculated "high tides". This interval is from 7:00 P. M., November 4th to 12:00 Noon, November 11th, Curve Sheets 1 to 5 inclusive. It will be noted that during this period the mud pressure was kept fairly close to 400 pounds, and that no visible disturbing influences were present. During this period it will be seen that the "Best" flows check the time of "rise" and "set" for the moon about as well as they check the "culmination" points. It is not essential that the "Best" flows should actually occur at the exact time specified for a maximum tidal influence. It is felt that the point is proven should an easily discernible harmony appear to exist between the "culmination" and the "Best" flows. That this harmony positively does exist is apparent from an inspection of the curves. During this period the "Best" flows check with amazing accuracy the calculated "high" tides.

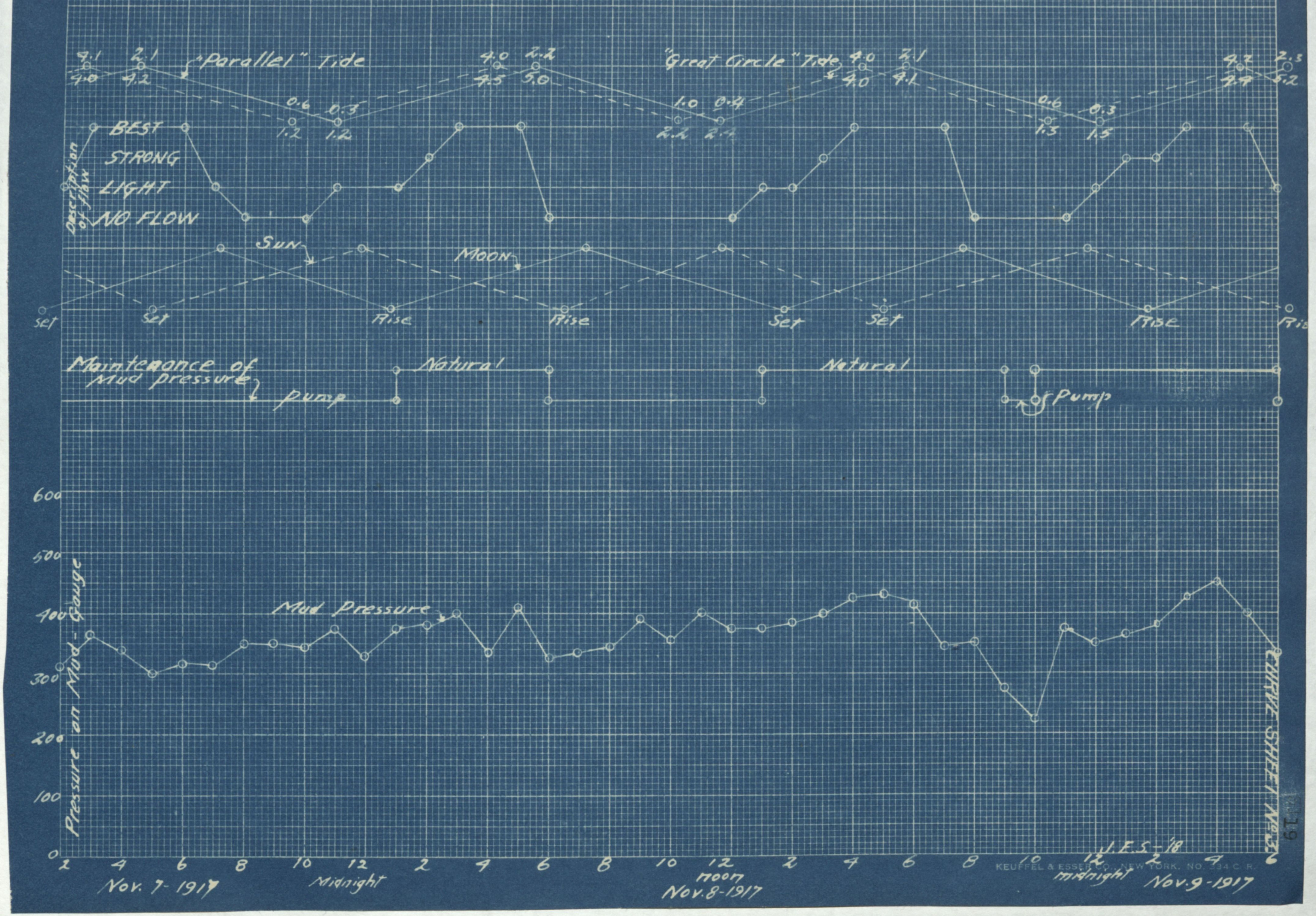
The facts recorded on the curves delineating the first eight days of the well's natural periodical flow are deemed sufficient to prove the tidal theory. The succeeding period shows certain variations, due to easily discernible external disturbing influences, which may seem to constitute arguments against the theory. These discrepancies are fully discussed in the attached Appendix B.

In summary, the following points are set forth: The water sand at the bottom of the Shriver No. 3 well having been subjected to an artificial pressure (gauge at top of ground) of 400 pounds per square inch, a natural periodic flow resulted from the well, inside the casing and outside the tubing, the source of this flow presumably being the oil sand immediately overlying the water sand. By means of the attached curve sheets, it has been shown that these natural periodic flows displayed an astonishingly well-marked harmonic relationship to the moon's passage on the meridian, thus bearing out the contention advanced by the writer that the tidal influence of the moon caused the well to flow periodically.

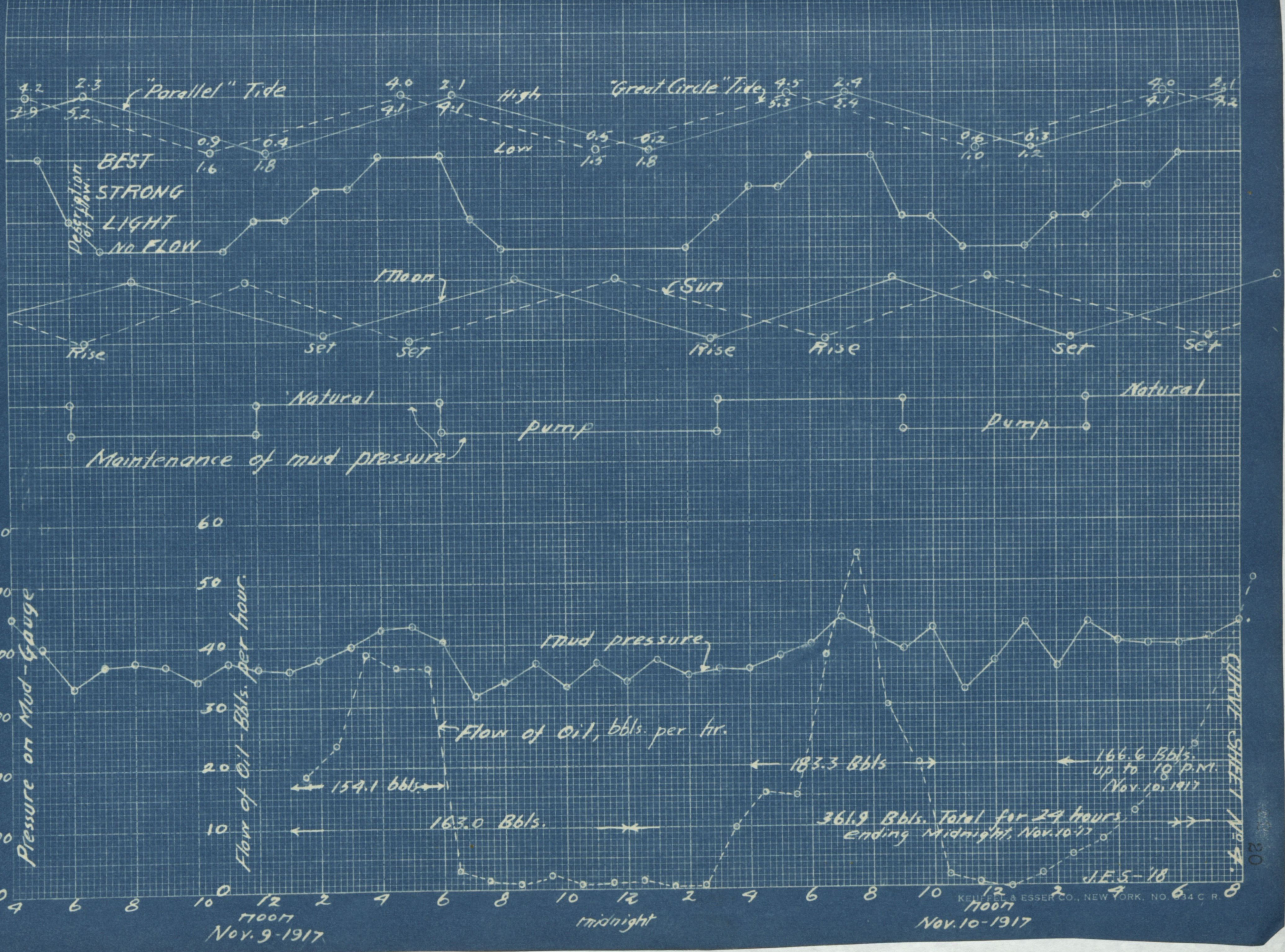


High
Tides
Low
"Parallel" Tide
"Great Circle" Tide
Description of Flow
BEST
STRONG
LIGHT
NO FLOW
Culmination
Moon & Sun
Rise & Set
Sun
Moon
set
set
Rise
Rise
Set
set
Rise
This Line indicates that pressure on mud was rising and falling Naturally
This Line indicates that pressure on mud was maintained by means of a pump
Natural
pumping
Pressure on Mud
Pressure on Mud-Gauge
600
500
400
300
200
100
0
10
12 noon
2
4
6
8
10
12 midnight
2
4
6
8
10
12 noon
2
4
6
8
10
12
2
midnight
Nov. 4-1917
Nov. 5-1918
J.F.S. '18
CURVE SHEET No. 1
KEUFFEL & ESSER CO., NEW YORK. NO. 359 C.R.

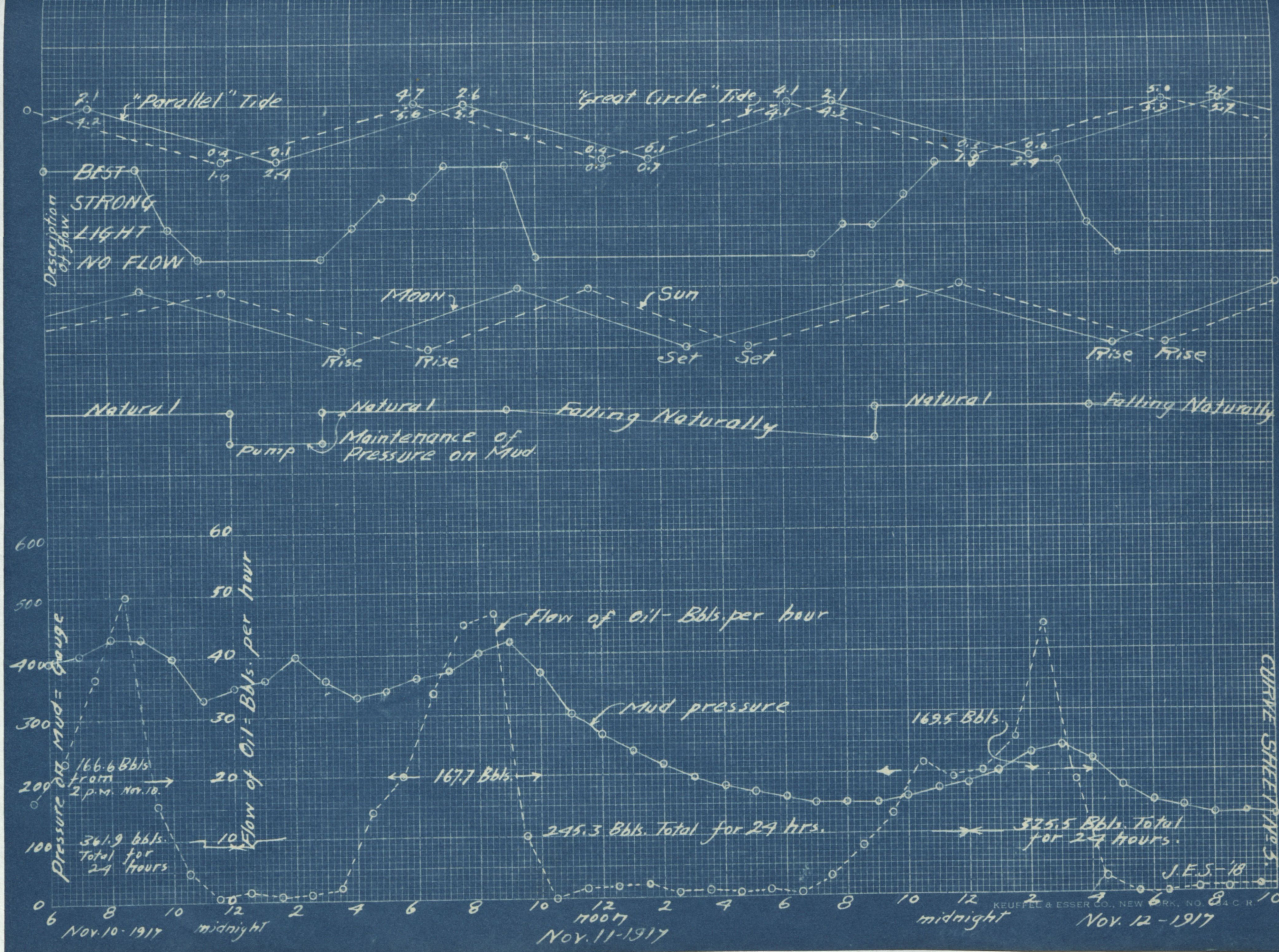

"Parallel" Tide
"Great Circle" Tide
HIGH
LOW
Description of Flow
BEST
STRONG
LIGHT
NO FLOW
Moon
Sun
Rise
Rise
set
set
Rise
Rise
set
set
Natural
Natural
Pump
Maintainence of Mud pressure
Mud pressure
Pressure on Mud-Gauge.
600
500
400
300
200
100
0
2
4
6
8
10
12
2
4
6
8
10
12
2
4
6
8
10
12
2
4
Noon
Nov. 6-1917
midnight
Noon
Nov. 7-1917
J.E.S.-'18
CURVE SHEET No. 2
KEUFFEL & ESSER CO., NEW YORK
18



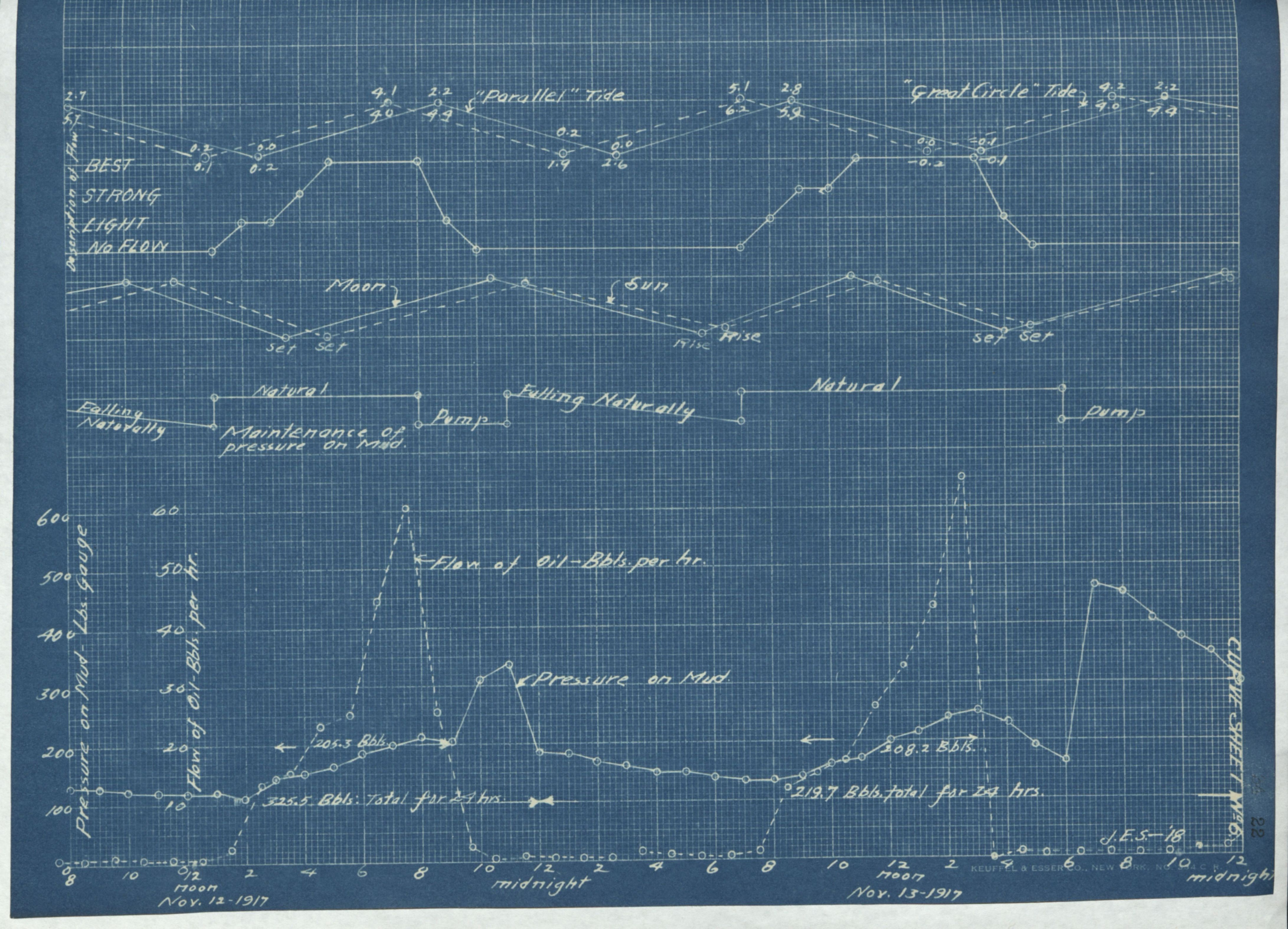
"Parallel" Tide
"Great Circle" Tide
Description of flow
BEST
STRONG
LIGHT
NO FLOW
Sun
Moon
Set
Rise
Maintenance of Mud pressure
Natural
pump
Pump
Mud Pressure
Pressure on Mud - Gauge
600
500
400
300
200
100
0
2
4
6
8
10
12
Nov. 7-1917
Midnight
Noon
Nov. 8-1917
Midnight
Nov. 9-1917
J.E.S.-'18
KEUFFEL & ESSER CO., NEW YORK. NO. 334 C. R.



"Parallel" Tide
"Great Circle" Tide
High
Low
Description of Flow
BEST
STRONG
LIGHT
No FLOW
Moon
Sun
Rise
Set
Natural
pump
Maintenance of mud pressure
Pressure on Mud-Gauge
Flow of Oil-Bbls. per hour.
Mud pressure
Flow of Oil, bbls. per hr.
154.1 bbls.
163.0 Bbls.
183.3 Bbls
166.6 Bbls. up to 10 P.M. Nov. 10, 1917
361.9 Bbls. Total for 24 hours ending Midnight, Nov. 10-17
J.E.S.-18
noon
midnight
Nov. 9-1917
noon
Nov. 10-1917
CURVE SHEET No. 4

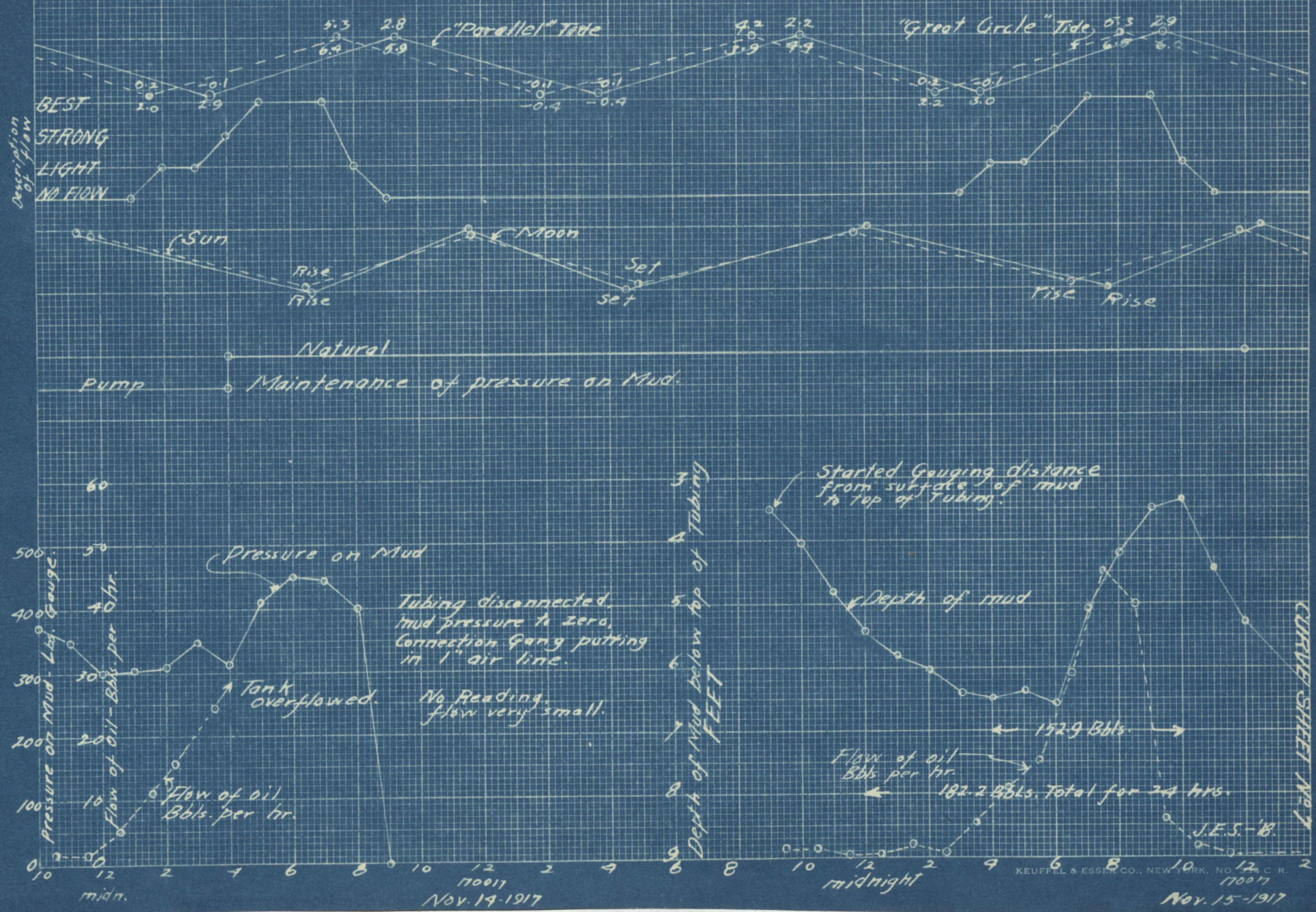


"Parallel" Tide
"Great Circle" Tide
2.1
4.2
4.7
5.6
2.6
3.5
0.4
1.0
0.1
2.4
0.4
0.5
6.1
0.7
4.1
4.1
2.1
4.3
0.5
1.8
0.0
2.4
5.0
5.9
2.7
5.7
Description of flow
BEST
STRONG
LIGHT
NO FLOW
Moon
Sun
Rise
Rise
Set
Set
Rise
Rise
Natural
pump
Natural
Maintenance of Pressure on Mud
Falling Naturally
Natural
Falling Naturally
Pressure on Mud = Gauge
Flow of Oil = Bbls. per hour
600
500
400
300
200
100
0
60
50
40
30
20
10
Flow of Oil - Bbls. per hour
Mud pressure
166.6 Bbls. from 2 p.m. Nov. 10.
361.9 bbls. Total for 24 hours
167.7 Bbls.
245.3 Bbls. Total for 24 hrs.
169.5 Bbls.
325.5 Bbls. Total for 24 hours.
J.E.S.-'18
6 8 10 12 2 4 6 8 10 12 2 4 6 8 10 12 2 4 6 8 10
Nov. 10 - 1917
midnight
noon
Nov. 11 - 1917
midnight
Nov. 12 - 1917
CURVE SHEET No. 3.
KEUFFEL & ESSER CO., NEW YORK, NO. 3[illegible]4 C. R.



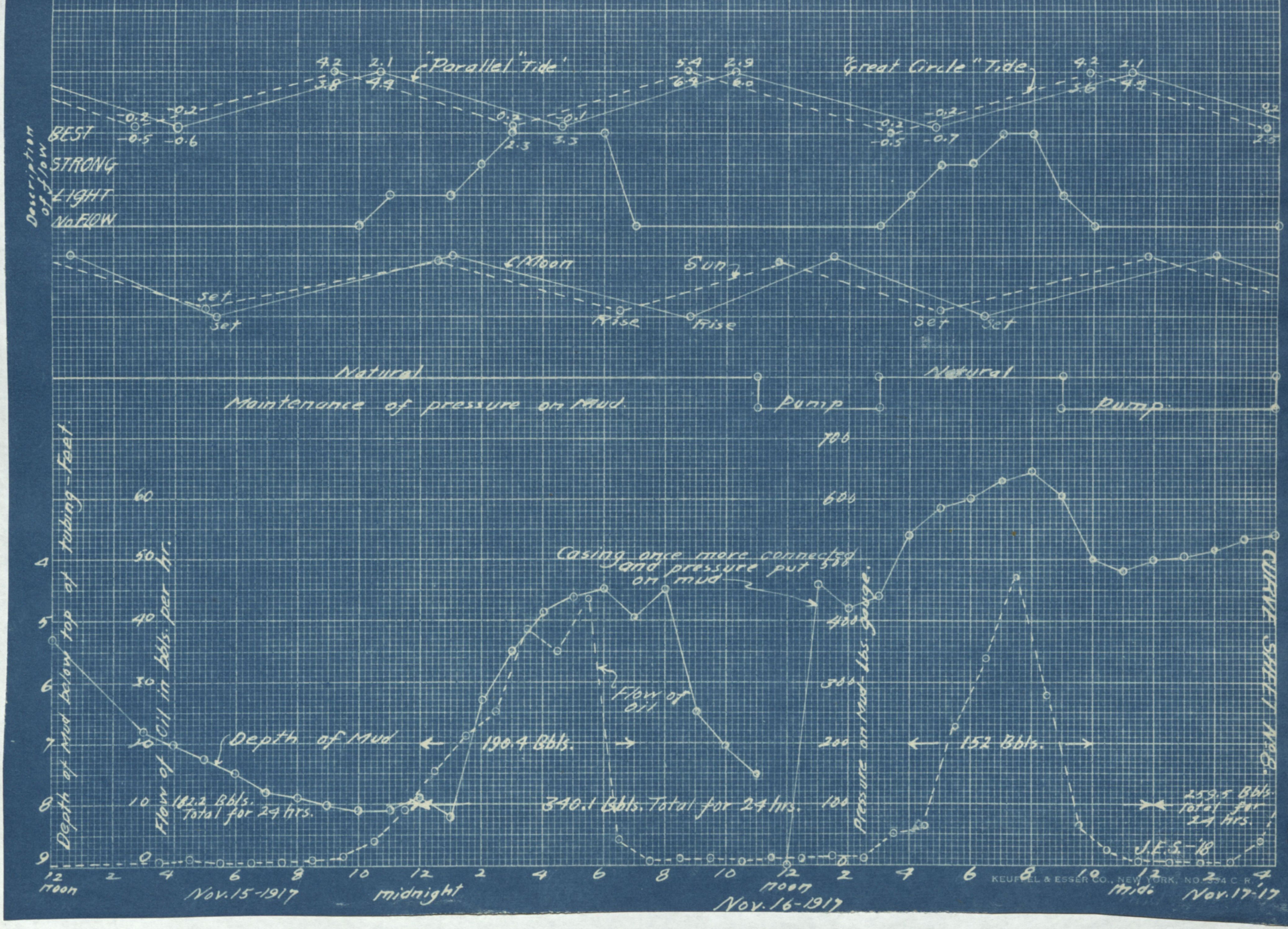
"Parallel" Tide
"Great Circle" Tide
Description of Flow
BEST
STRONG
LIGHT
No FLOW
Moon
Sun
set
set
Rise
Rise
set
set
Falling Naturally
Natural
Maintenance of pressure on Mud.
Pump
Falling Naturally
Natural
pump
Pressure on Mud - Lbs. Gauge
Flow of Oil - Bbls. per hr.
Flow of Oil - Bbls. per hr.
Pressure on Mud
205.3 Bbls.
325.5 Bbls. Total for 24 hrs.
208.2 Bbls.
219.7 Bbls. total for 24 hrs.
noon
Nov. 12-1917
midnight
noon
Nov. 13-1917
midnight
J.E.S.-'18
CURVE SHEET No 6

22



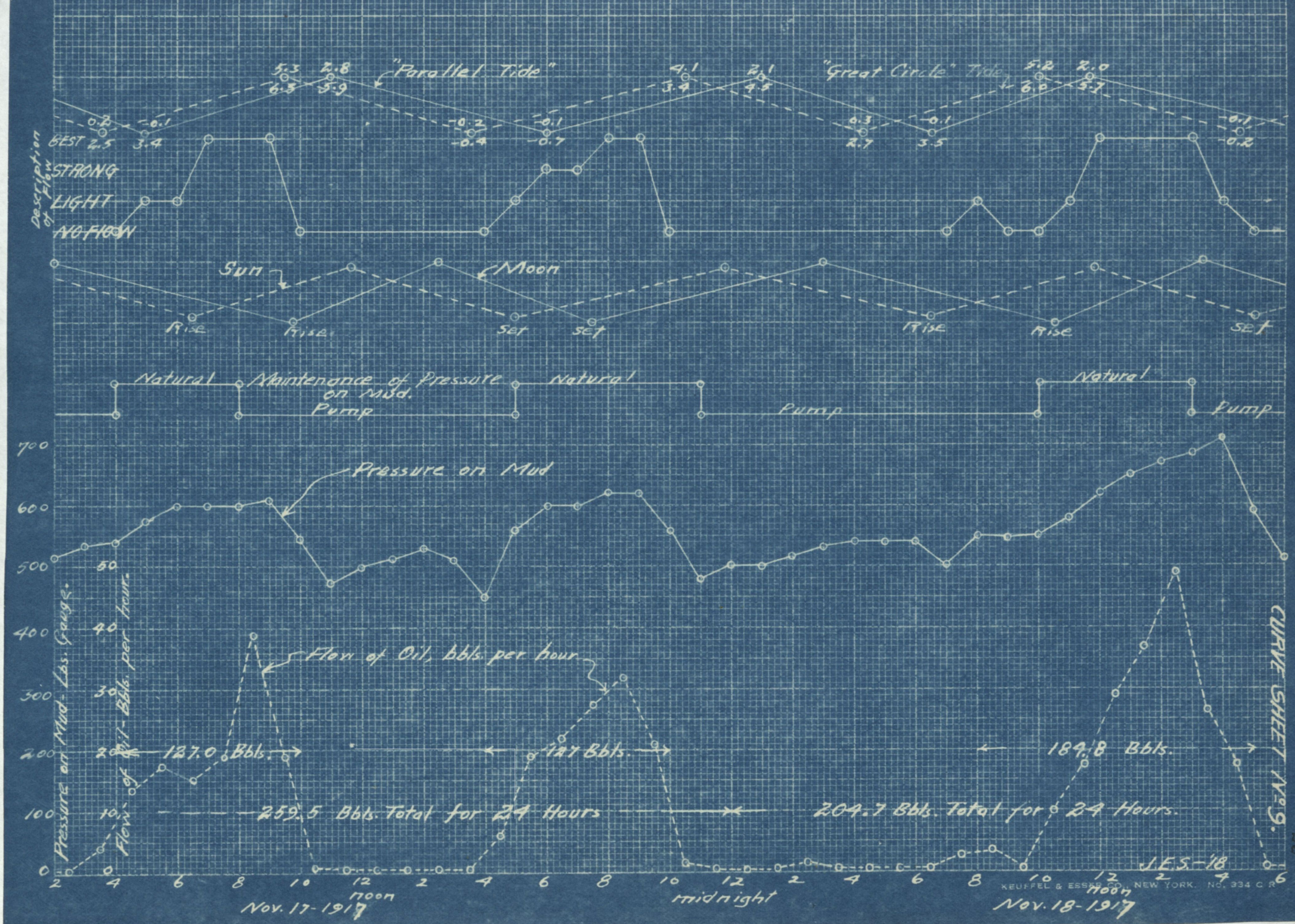
"Parallel" Tide
"Great Circle" Tide
5.3
2.8
6.4
5.9
0.2
1.0
-0.1
2.9
-0.1
-0.4
-0.1
-0.4
4.2
2.2
3.9
4.9
0.2
2.2
-0.1
3.0
0.3
2.9
6.9
6.0
Description of flow
BEST
STRONG
LIGHT
NO FLOW
Sun
Moon
Rise
Rise
Set
Set
Rise
Rise
Natural
Pump
Maintenance of pressure on Mud.
Started Gauging distance from surface of mud to top of Tubing.
Pressure on Mud
Tubing disconnected, mud pressure to zero, Connection Gang putting in 1" air line.
Tank overflowed.
No Reading. flow very small.
Flow of oil Bbls. per hr.
Depth of mud
152.9 Bbls.
Flow of oil Bbls per hr.
182.2 Bbls. Total for 24 hrs.
J.E.S.-'18.
CURVE SHEET No-7
Pressure on Mud - Lbs. Gauge.
Flow of Oil - Bbls. per hr.
Depth of Mud below top of Tubing FEET
500
400
300
200
100
0
60
50
40
30
20
10
3
4
5
6
7
8
9
10
12
2
4
6
8
10
12
2
4
6
8
10
12
2
4
6
8
10
12
2
midn.
noon
midnight
noon
Nov. 14-1917
Nov. 15-1917
KEUFFEL & ESSER CO., NEW YORK. NO. 358 C.R.

23

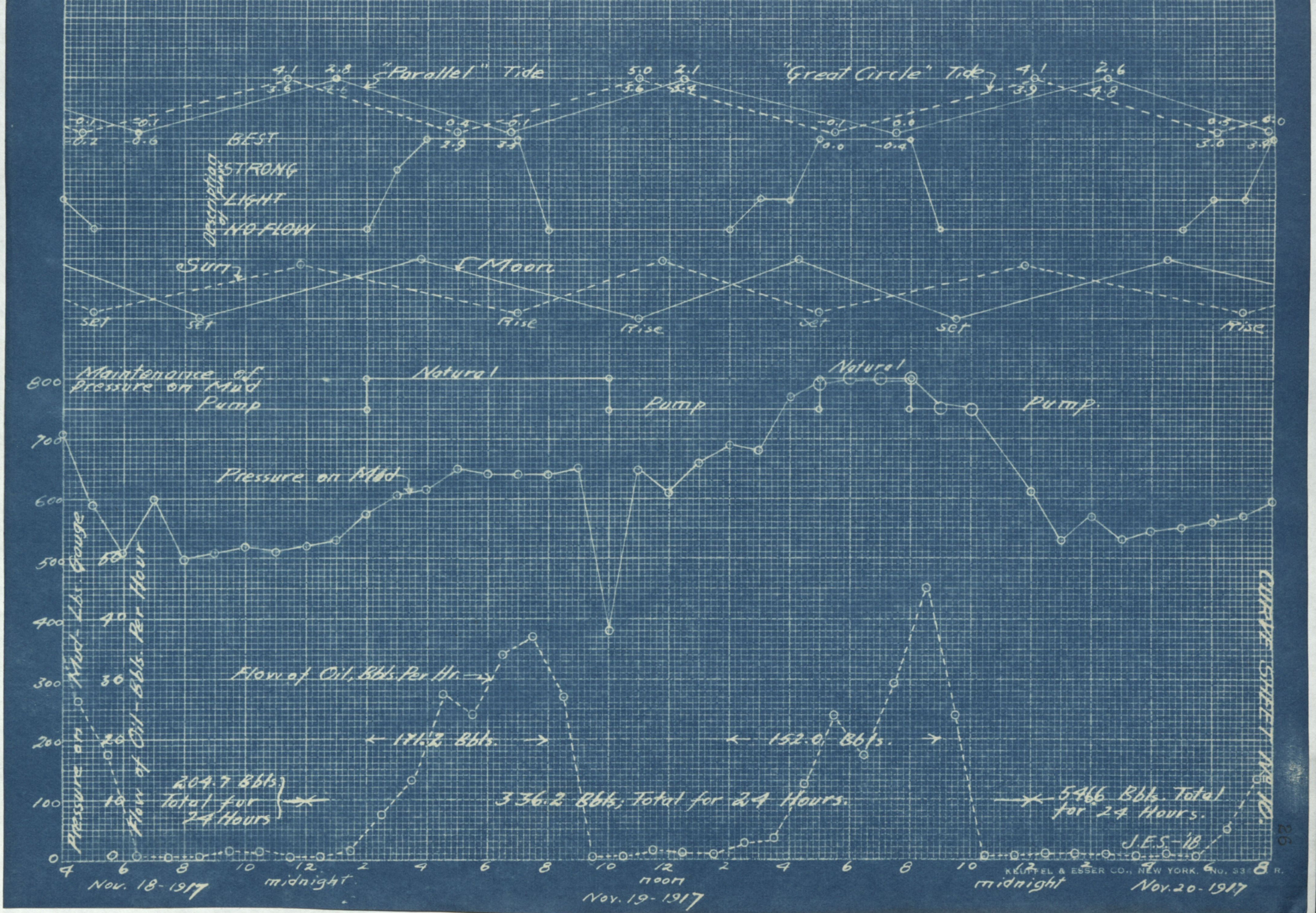


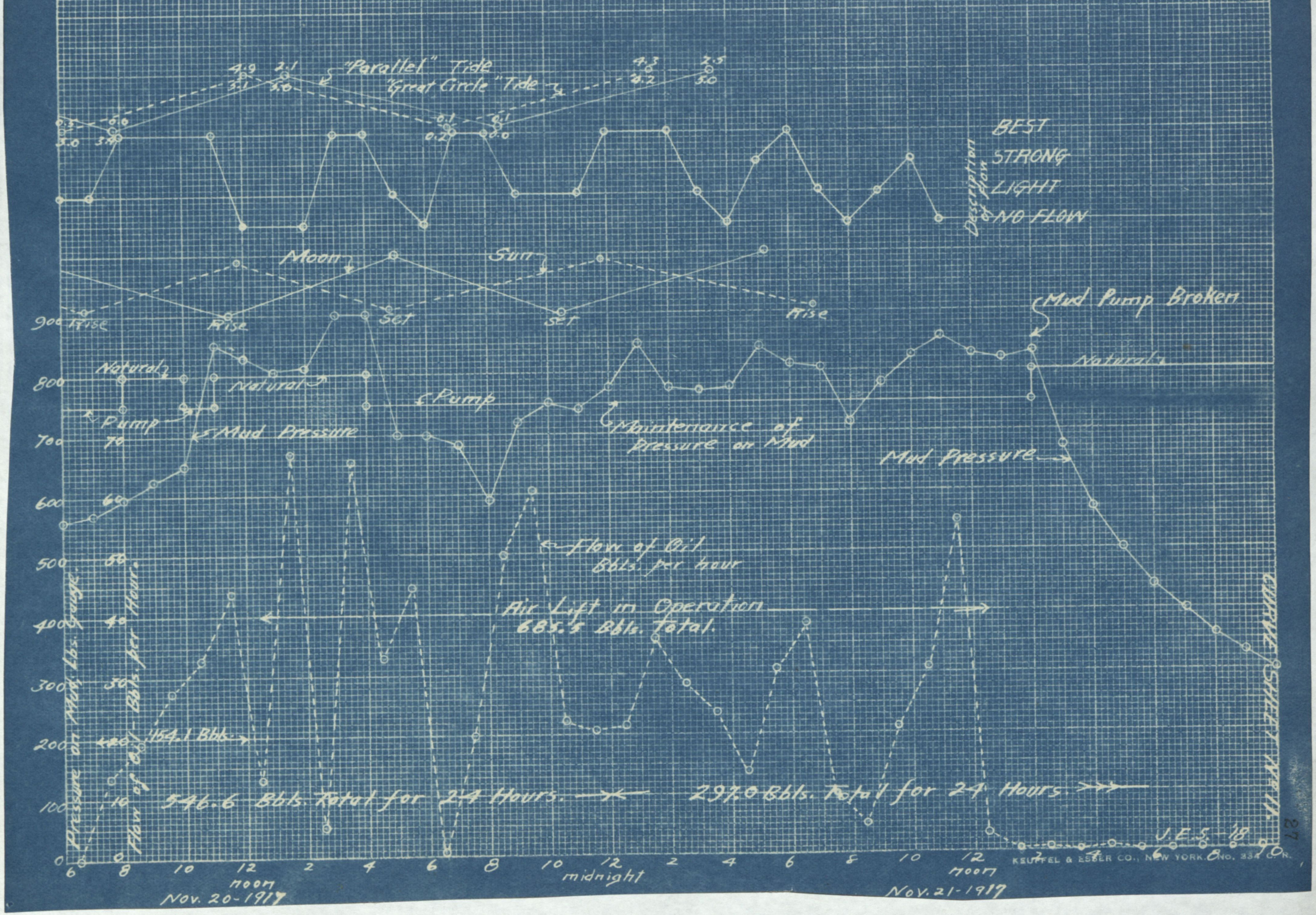
"Parallel" Tide
"Great Circle" Tide
Description of flow
BEST
STRONG
LIGHT
No FLOW
Moon
Sun
Set
Rise
Natural
Maintenance of pressure on Mud.
Pump
Depth of Mud below top of tubing - Feet.
Flow of Oil in Bbls. per hr.
Pressure on Mud Lbs. gauge.
Casing once more connected and pressure put on mud
Flow of Oil.
Depth of Mud
190.4 Bbls.
152 Bbls.
182.2 Bbls. Total for 24 hrs.
340.1 Bbls. Total for 24 hrs.
259.5 Bbls. Total for 24 hrs.
J.F.S.-18
12 noon
midnight
noon
Mid.
Nov. 15-1917
Nov. 16-1917
Nov. 17-17
CURVE SHEET NO. 6
KEUFFEL & ESSER CO., NEW YORK, NO. 354 C. R.

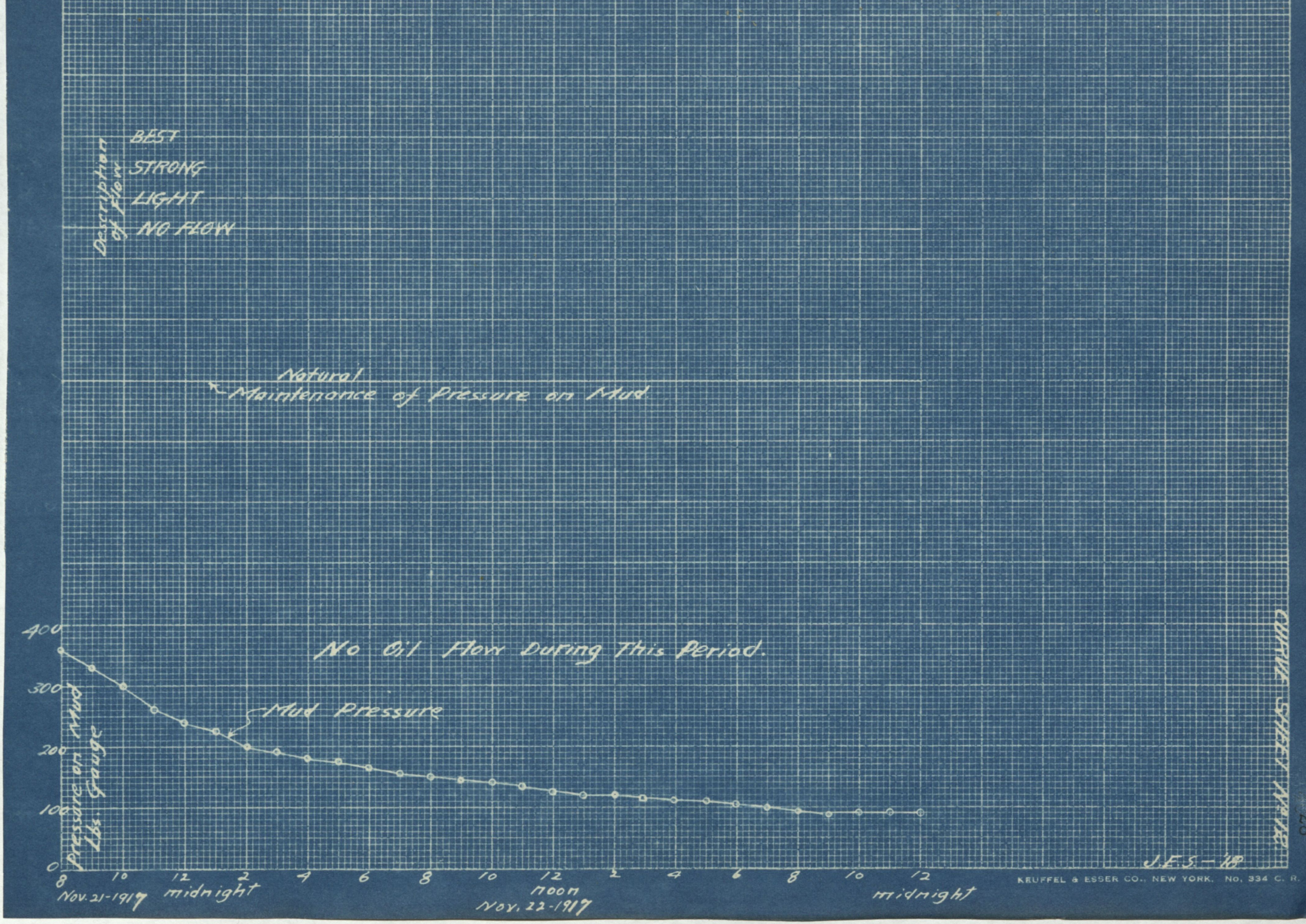
24


"Parallel Tide"
"Great Circle" Tide
Description of Flow
BEST
STRONG
LIGHT
NO FLOW
Sun
Moon
Rise
Set
Natural
Maintenance of Pressure on Mud.
Pump
Pressure on Mud
Flow of Oil, bbls per hour
127.0 Bbls.
147 Bbls.
184.8 Bbls.
259.5 Bbls. Total for 24 Hours
204.7 Bbls. Total for 24 Hours.
Pressure on Mud - Lbs. Gauge.
Flow of Oil - Bbls. per hour.
noon
midnight
Nov. 17-1917
Nov. 18-1917
J.E.S.-18
CURVE SHEET No. 9.
KEUFFEL & ESSER CO. NEW YORK. No. 334 C R

25


"Parallel" Tide
"Great Circle" Tide
BEST
STRONG
LIGHT
NO FLOW
Description of Flow
Sun
Moon
Set
Rise
Maintenance of Pressure on Mud
Natural
Pump
Pressure on Mud
Flow of Oil, Bbls. Per Hr.
171.2 Bbls.
152.0 Bbls.
204.7 Bbls. Total for 24 Hours
336.2 Bbls. Total for 24 Hours.
546.6 Bbls. Total for 24 Hours.
J.E.S.-'18
Pressure on Mud-Lbs. Gauge
Flow of Oil-Bbls. Per Hour
Nov. 18-1917
midnight
noon
Nov. 19-1917
Nov. 20-1917
CURVE SHEET No. 10.
KEUFFEL & ESSER CO., NEW YORK.


"Parallel" Tide
"Great Circle" Tide
BEST
STRONG
LIGHT
NO FLOW
Description of Flow
Moon
Sun
Rise
Set
Mud Pump Broken
Natural
Pump
Mud Pressure
Maintenance of Pressure on Mud
Flow of Oil Bbls. per hour
Air Lift in Operation
685.5 Bbls. Total.
154.1 Bbls.
546.6 Bbls. Total for 24 Hours.
297.0 Bbls. Total for 24 Hours.
Pressure on Mud, Lbs. Gauge
Flow of Oil Bbls. per Hour.
CURVE SHEET WELL
J.E.S. -18
KEUFFEL & ESSER CO., NEW YORK. NO. 334 C.R.
noon
midnight
Nov. 20-1917
Nov. 21-1917



Description of Flow
BEST
STRONG
LIGHT
NO FLOW
Natural Maintenance of Pressure on Mud
No Oil Flow During This Period.
Mud Pressure
Pressure on Mud Lbs. Gauge
400
300
200
100
0
8
10
12
2
4
6
8
10
12
2
4
6
8
10
12
Nov. 21-1917
midnight
noon
Nov. 22-1917
midnight
J.E.S.-'18
CURVE SHEET No.
KEUFFEL & ESSER CO., NEW YORK. No. 334 C. R.

APPENDIX A

A DISCUSSION ON TIDES.

APPENDIX A

A Short Discussion

Regarding Tides.

In the words of the encyclopaedia, the word "tide" denotes an elastic or viscous periodic deformation of a solid or viscous globe under the action of tide generating forces. The term "globe" is understood to embrace the solid earth, the water of the sea, and the atmosphere surrounding both. The tide generating potential varies as the square of the distance from the earth's center, and the corresponding forces act at every point throughout its mass. No solid matter possesses the property of absolute rigidity, and we must therefore admit the probable existence of tidal elastic deformations of the solid earth itself. Hence in this paper the word "tide" will be used, in places, to include the theoretical swelling of the earth itself, due to the lunar attraction. Some time after the writer's observations on Shriver No. 3, and after the curves shown in this paper had been prepared, it was learned that several observers had demonstrated by physical means that the surface of the earth actually does rise and fall about a foot under the action of the tidal influence. The time of maximum rise agrees very closely with the calculated time of maximum influence. Professor A. A. Michelson of the University of Chicago has probably shown the latest and best results on this phenomenon. In ordinary usage a tide is defined as a rise and fall of the water of the sea produced by the attraction of the moon and sun. There are various kinds of tides; for instance, in meteorlogical tides there are strongly marked diurnal and semi-diurnal inequalities in barometric pressure, due to the sun's effect as a radiating body upon the earth. In this connection it is worthy of note that variations in barometric pressure cause departures from the predicted height of water, where high barometer corresponds to decrease in height of water. No barometric readings were taken during the time the Shriver No. 3 was under the writer's observation. It is quite possible that the atmospheric influence was negligible, as compared with the tidal forces, but nevertheless it would be interesting to know what variations, if any, occurred in atmospheric pressure during the month or so that the natural flow of the well was periodic. Tides, as defined in this paper, are caused by the gravitational attraction or pull of the moon and sun upon the earth. Since the recorded phenomena of tides are based upon

Pp. 20 to 30 misplaced
between pp. 45 & 46.

the water or ocean tides, the present discussion will include water tides, as well as earth tides. The moon, being so much nearer than the sun, is of course the principal cause. When the moon is directly over a given place it pulls the water under it, and thus tends to heap up a tidal wave just under the moon. At the same time it is pulling the earth itself, but it pulls the water more than the earth underneath, because, first, the water is nearer to the moon than is the earth, and second, because the earth has a much greater rigidity than the water. The first reason is explained by Newton's law of attraction, which states that the pull decreases rapidly when the body pulled is removed to a greater distance. But this reason also makes the attraction exerted upon the solid earth greater than that affecting the mass of water upon the side of the earth opposite the moon. This water, being still farther away than is the solid earth, gets the least pull of all. These circumstances cause another distinct heaping up of the water opposite to the moon, giving us a second tidal wave. There should be, therefore, two lunar tidal-wave crests, one directly under the moon and the other on the side of the earth opposite the moon. This explanation is modified somewhat on account of the attraction of the sun, which at times tends to increase, and again at times to decrease, the lunar tide. We thus get the high tides of new and full moon, called "spring" tides, and the low tides, called "neap" tides, of certain other ages of the moon. Under this explanation of tides, which is called the "equilibrium" theory of tides, we should expect high water at any place about the time when the moon passes the meridian. This is not in accord with observation on ocean tides, since there are places where a high tide comes as much as six hours away from the meridian passage of the moon. This seeming discrepancy is accounted for by the theory of the motion of fluid waves, called the "dynamic" theory of the tide, and is worded as follows: "If a quickly varying periodic force acts on a system which would oscillate slowly if left to itself, the maximum excursion on one side of the equilibrium position occurs simultaneously with the maximum force in the direction opposite to that of the excursion". As intimated above the effects of nature modify considerably the theoretical tidal action of sun and moon. The barometric pressure, winds, depth of ocean, slope of coast, and many other things are to be considered. It is therefore impossible to predict the times of high water accurately from theoretical considerations alone. This can be done only by analysis of a long period of observations. The U. S. Coast and Geodetic Survey has for many years observed the ocean tides at various places, and now issues Tide Tables for a number of localities. These tables attempt to predict the time and height of high and low water. The tables also give the time of moon-rise and moon-set, and the time of sun-rise and sun-set, for a number of localities.

APPENDIX B

THE DISCREPANCIES.

APPENDIX B

The Discrepancies.

During the latter portion of the time shown on the curves, or from 12:00 Noon, November 11th to 12:00 Noon, November 20th, (Curve Sheets 5 to 11, inclusive) the "description" and "tide" or "culmination" curves do not check as well as they do in the earlier period shown on the curves, which discrepancies may have been due to certain external influences that are well shown on the curve. During this interval there are four flows which do not seem to harmonize: those of 3:00 A. M., November 12th (Curve Sheet No. 5); 3:00 P. M. November 13th (Curve Sheet No. 6); 5:00 A. M., November 16th (Curve Sheet No. 8); and 5:00 A. M., November 19th (Curve Sheet No. 10). In addition there is a fifth discrepancy where absolutely no flow occurs, that of 8:00 P. M. November 14th (Curve Sheet No. 7). It seems certain that these discrepancies can be easily explained, granting the practically universal harmony which prevails during the earlier period shown on the curves, when conditions remained constant, and noting the disturbing features attendant upon the latter part of the curves. It will be seen that during this latter interval the pressure on the mud did not remain constant for any length of time sufficient to insure a regular frequency of flow, and this probably must be the principal basis for explaining the discrepancies. Of course it is quite possible that other disturbances unknown to the observers may have had their influence on the flow, which if known might serve to further clear up the difficulty. As an instance it may be stated that we know practically nothing concerning operations, conditions, and flows at surrounding oil wells during the observation period. Nor have we any knowledge of temperature atmospheric pressure, and other things which might be worthy of consideration.

Taking up the first discrepancy, that of 3:00 A. M. November 12th (Curve Sheet No. 5) a possible explanation may be reached by saying that the flow coincides exactly with the calculated time at which a "half" tide occurs to which reference was made above. By this is meant that this flow occurs exactly at the time calculated for a "low" tide, but this "low" tide has a mean heighth considerably greater than either of the adjacent "low" tides. At the end of the preceding flow, that of 9:00 A. M. November 11th, (Curve Sheet

No. 5) it was decided to maintain no longer the artificial 400 pound pressure on the mud, but to permit the pressure to rise and fall of its own accord and to observe the results. In this connection the writer wishes to state that he had no voice in the general policy governing the observations, or the procedure to be followed as to maintenance of mud pressure and similar items. In this particular instance the resulting steady drop in mud pressure is well shown by the curve, and what seems to have been the immediate result is shown by the six hours delay in the time of arrival of the next flow. The succeeding flow, that of 8:00 P. M. November 12th (Curve Sheet No. 6) arrived at the appointed time, coinciding nicely with a calculated "high" tide.

The next flow, the second of the five discrepancies noted above occurs at 3:00 P.M. November 13th (Curve Sheet No. 6). If an attempt be made to explain this by the method employed in treating the flow of 3:00 A. M. November 12th (Curve Sheet No. 5) we are at a loss, for the former flow does not occur at a "half" tide, as does the latter. However the flow does check nicely with a "spring" tide as shown by the sun and moon culminations.

The third discrepancy, that of 8:00 P. M. November 14th (Curve Sheet No. 7) where no flow occurs at the appointed time, may be explained by the fact that all pressure on the mud was removed at the conclusion of the preceding flow (6:00 A. M. November 14th, Curve Sheet No. 7).

The next flow, that of 8:00 A. M. November 15th (Curve Sheet No. 7) occurs exactly as predicted, while the following flow, that of 5:00 A. M. November 16th (Curve Sheet No. 8) makes the fourth discrepancy. But this again occurs at the time of a "half" tide, thus restoring the harmonies.

The fifth discrepancy, that of 5:00 A. M. November 19th (Curve Sheet No. 10) again occurs simultaneously with a "half" tide.

APPENDIX C

THE INFLUENCE OF PRESSURE.

APPENDIX C

The Influence of Pressure.

It will be noted that during the period of observation recorded on these curves we have four sets of intervals wherein the pressure on the mud may be said to have been fairly constant. These pressures are zero (Curve Sheet No. 7, 9:00 A. M. November 14th to 12:00 Noon, November 16th, Curve Sheet No. 8), 400 pounds (Curve Sheet No. 1, 7:00 P. M. November 4th to 9:00 A. M. November 11th, Curve Sheet No.5), and 550 pounds (Curve Sheet No. 8, 4:00 P. M. November 16th to 8:00 A. M. November 20th, Curve Sheet No. 10). During the period wherein the pressure was maintained at practically 400 pounds, conditions were constant during such a length of time that it may reasonably be concluded that the data shows a record of the true natural function, but the time period of the other three pressures was entirely too short, in the writer's opinion, for the flow of the well to arrive at a true natural conditon of periodicity. It seems safe to conclude that had external conditions remained constant for a sufficient period during the intervals of zero, 150, and 550 pound pressures, then the well would have exhibited natural periodic flows harmonizing within reasonable limits with the tidal influence. Indeed, the curves show in so far as the available data permits, that a decided harmony did exist, no matter what the pressure, the discrepancy lying in the fact that the periodicity of the flows did not check with the periodicity of the tidal influence.

As stated before it is thought that any pressure maintained on the mud for a length of time sufficient to produce a natural condition will result in a harmonic periodicity with the tidal influence. This statement calls for some slight analysis of the well's performance, based in a position upon the assumption that the tidal influence is inherently active in producing the periodical flows, and taking into account artificial pressure variations.

As intimated in the preceding pages it seems reasonable to suppose a break in the seal between the water and oil sands. The heaping up of the earth in harmonic period throughout the day must be accepted as a fact. The same influence that causes this "heaping up" of the earth will of course heap up both the oil and water in their respective sands.

Let it be supposed that the seal between the two sands is broken at some distance from the well, and down the dip of the strata. Then we may expect to find water at that place in the oil sand. Now, since hydrostatic pressure is exerted equally in all directions, if an external pressure be applied on the mud, this pressure might be concieved of as acting thru the water sand to the break, and thus forcing the general level of the oil in the oil sand farther up that stratum towards the well. In a general way this can be concieved as raising the general effective level of the oil in the oil sand. Therefore, when the tidal influence is exerted, the well flows. Since some oil has been removed from the well, the oil must be considered as gradually seeping thru the sand in the direction of the well, and always attempting to maintain a certain level at the well. Now let the artificial pressure on the mud be decreased and as a natural consequence a corresponding lowering of the general effective oil level must be expected. This circumstance is illustrated on the curve by the pressure drop starting at 9:00 A. M. November 11th (Curve Sheet No. 5). Under the tidal theory of flow another flow of oil might be expected from the well at the next calculated "high" tide, which occurs at 7:00 P. M. November 11th (Curve Sheet No. 5). But the oil does not seep in fast enough to counteract the lowering of the general effective oil level due to the decreased pressure, and therefore no flow is recorded at the predicted time. However, a flow is obtained at 3:00 A. M. November 12th, (Curve Sheet No. 5) which time corresponds exactly with a predicted "half" tide. Suppose the velocity of the oil traveling thru the sand towards the well be increased by reason of the diminished height of the oil at the well. As stated above, this is not sufficient to produce the quantity required at the well to obtain a flow at the time of a calculated "high" tide. But the sun and moon are rapidly approaching the simultaneous culmination needed for a "spring" tide, consequently "low" tide is a foot or two higher than the preceding "low" tide; of course the tendency to flow must be present,(according to the "dynamic" theory), and therefore the flow occurs at a "half" tide. The decrease in pressure following this flow is not so rapid as the decrease preceding the flow, thus indicating a tendency towards a static condition in the water sand, therefore the next flow is found to harmonize nicely with a calculated time of "high" tide. But the continued drop in pressure brings conditions more and more closely to what may be called the "normal condition", and the next flow, that of 3:00 P. M. November 13th (Curve Sheet No. 6) occurs at the time calculated for a "low" tide. To the writer this circumstance simply shows that the pressure on the oil must be of considerable moment in delaying or hastening the results to be expected from lunar attraction. The writer is not yet prepared to state whether this pressure is to be regarded as bringing forward a condition similar to that obtaining in a large open body of water under which the dynamic theory must be used to explain the delay in high tide, or whether the addition of pressure brings about a condition applicable to the equilibrium theory, under which the maximum result is to be expected practically coincident with the maximum influence. However it does seem certain that if the 200 pounds pressure which is found on the mud at this time (November 13th, Curve Sheet No. 6) had been maintained for several days, the well would soon have settled down to an easily discerned harmonic tidal relationship. It seems safe to make the assertion that no matter what the pressure, if condition became constant, the harmonic tendency would certainly appear. It may be that with no pressure the flow is to be expected considerably later than the calculated tide; with increased pressure, somewhat nearer this time, and with a still greater increase in pressure, the flow would occur still closer to the predicted time. Or, on the other hand, the second method of explaining the influence of pressure, as outlined above, may be the true cause, to the effect that the harmonics will be plainly discernible, but that the periodicity of flow will not check the periodicity of lunar attraction. In all cases, however, the flows immediately following decided change in pressure might vary from a predicted time, while within a couple of days or so the frequency of flow might again harmonize with the calculated tides. This view is sustained by the two flows following the one last mentioned. The first, that of 7:00 A. M. November 14th, (Curve Sheet No. 7) occurs some sixteen hours after the preceding flow (that of 3:00 P. M. November 13th) and practically checks with the time of a calculated tide. The difference in time between the two preceding flows (8:00 P. M. of the 12th and 3:00 P.M. of the 13th, Curve Sheet No. 6) is ninteen hours. That the time of flow should be brought forward and that this time should coincide closely with a predicted tide is to be expected, since the mud pressure has been artificially raised from 150 pounds to 450 pounds.

Second circumstance which checks the first idea concerning the influence of pressure is recorded on the curve under the date of 10:00 P. M. November 14th (Curve Sheet No. 7). At 8:00 A. M. of this day all artificial pressure was removed from the mud, therefore a delayed flow must be expected. As shown by the curve, one entire period is missed, there being no flow at the predicted time of 10:00 P.M. November 14th (Curve Sheet No. 7). This checks the circumstances of delayed flow due to decreased pressure shown by the flow of 3:00 A.M. November 12th (Curve Sheet No. 5). The two flows next discussed (November 15th) serve to illustrate the truth that harmonics must exist between the times of flows but that such times cannot accurately be predicted from theoretical considerations above. The first of these flows, that of 8:00 A. M. November 15th (Curve Sheet No. 7) occurs simultaneously with a predicted tide; the next "high" tide is missed since the second flow, that of 5:00 A. M. of the 16th (Curve Sheet No. 8) occurs at a calculated time of low tide. This flow, however, harmonizes with a "spring" tide tendency. Following this flow an artificial pressure averaging around 530 pounds was placed on the mud, and thereafter, with minor exceptions, the flows and calculated tides check with reasonably accuracy.

APPENDIX D

GEOLOGICAL FEATURES OF THE ELDORADO FIELD

BY

A. W. McCOY.

APPENDIX D

Geological Features of the ElDorado Field

By

A. W. McCoy.

The Towanda dome of the ElDorado Field is situated in the extreme northeast corner of Township 26 south, range 4 east. The dome is elongated in a northeast - southwest direction, extending through section 1, southeast corner of section 2, the northwest corner of section 12 and into section 11. The formations dip away in all directions from the high area, sections 13, 14, 15, 10 and 3, border the outside edge of the dome. Outcrops of the Winfield formation occur in sections 14 and 11, dipping to the southwest. The Shriver well number 3 is located about 25 feet below a massive ledge of the Winfield limestone.

The stratified or sedimentary rocks in Butler county aggregate about 3000 feet in thickness in the region of the ElDorado field. The upper twenty-three or twenty-four hundred feet of these sediments is largely shale with some limestone. The Varner or Stapleton sand occurs at a depth of about 2400 feet; from there down to the granite, which is a varying distance of 500 to possibly 1500 feet, the sediments are composed largely of sandstone with cherty zones.

The productive part of the horizon is in the top of this thick sand just below the shale at the 2400 feet depth. The pay sands are porous streaks (with possibly occasional cavities) varying from two to five or ten feet in thickness, running over a considerable area, horizontally. Between these open pay sands, there are hard impervious layers, sometimes shaly and sometimes without apparent shale. In some places there are as many as three of these pay streaks encountered. This sandstone body runs northeast-southwest parallel to the shore of an old basin; the sand having been brought in from the west. To the east of ElDorado and Augusta this sandstone thins out rapidly into the shale with thin limestones.

The total sand zone is completely saturated with salt water; the oil occupies only the more porous layers within fifty feet of the top. The water in the sandstone is very close in analysis to that of sea water, averaging about 35,000 parts per million total solids with about ten percent sulphate salinity. The water in these lower formations is completely trapped and under pressure (probably due to settling). The lower waters differ materially from any waters in the upper water horizons as those in the upper zones occur in thin lenticular bodies of porous formations. The waters themselves have been considerably changed from original sea water, carrying a high content of total solids, averaging about 150,000 parts per million.

TABLE NO. 1.
Page 1.

RECORD OF WELL NUMBER 3

On J. Shriver Farm,
Section 14, Township 26, Range 4, Butler
County, Kansas.

Nature of Strata	Color	Hard	Thickness	Total Depth	Remarks
Lime	White	Hard	6	120	2 bailers water
Red rock	red	soft	6	126	
lime shell	white	hard	6	132	
slate	blue	soft	8	140	
red rock	red	"	10	150	
lime shell	white	hard	5	155	
slate	blue	soft	40	195	
slate & lime shells	"	"	45	240	
lime	white	hard	65	305	
slate	blue	soft	25	330	
lime	white	hard	12	432	
slate	blue	soft	78	510	
lime shell	white	hard	5	515	
red rock	red	soft	20	535	
slate	blue	"	115	650	
lime shell	white	hard	12	662	7 bailers water
slate	blue	soft	68	730	
lime	white	"	20	750	
slate	blue	soft	6	756	
lime	white	"	6	762	
slate	blue	"	53	815	
slate and shells	"	"	85	900	
lime	white	hard	25	925	
slate	blue	soft	10	935	
slate & shells	"	"	25	960	
slate	"	"	100	1060	1 bailer water
lime	white	hard	60	1120	
slate	blue	soft	20	1140	
lime	white	"	100	1240	8 bailers water
slate	blue	"	10	1250	
lime	white	"	90	1340	
slate	blue	soft	5	1345	

TABLE NO. 1.
Page 2.

RECORD OF WELL NUMBER 3 (CONT'D).

Nature of Strata	Color	Hard	Thickness	Total Depth	Remarks
lime	white	hard	55	1400	
slate	blue	soft	25	1425	
lime	white	"	35	1460	
slate	blue	"	102	1562	
lime	white	hard	8	1570	
slate	blue	soft	30	1600	
lime	white	hard & soft	220	1820	
slate	blue	soft	125	1945	
lime	black	hard	65	2010	4 bailers water & Oil
water sand	white	soft	20	2030	20 bailers water
lime	"	hard	56	2086	hole full water
slate	blue	soft	114	2200	
slate & shells	"	"	75	2275	
slate	pink	soft	58	2333	
stapleton sand	white	hard	35	2368	

TABLE NO. 2.
Page 1.

LOG OF SHRIVER # 3.

Nov. 4th, 1917.			
7 PM	300#	No Flow	Pump
8	335	"	"
9	325	"	"
10	315	"	"
11	300	"	"
12	300	Light	"
Nov. 5th, 1917.			
1 AM	400#	Stronger	Natural
2	390	Good Flow	"
3	350	"	"
4	290	No Flow	Pump
5	325	"	"
6	320	"	"
7	350	"	"
8	385	"	"
9	400	Light	"
10	420	"	"
11	375	"	"
12 Noon	375	Stronger	Natural
1 PM	420	Strong	"
2	390	"	"
3	390	No Flow	Pump
4	400	"	"
5	380	"	"
6	370	"	"
7	350	"	"
8	390	"	"
9	400	"	"
10	390	Light	"
11	400	Strong	"
12 Night	390	"	"

TABLE NO. 2.
Page 2.

LOG OF SHRIVER #3 (CONT'D).

Nov. 6th, 1917.			
1 AM	400#	Strong	Natural
2	440	No Flow	"
3	375	"	"
4	380	"	Pump
5	420	"	"
6	400	"	"
7	350	"	"
8	375	"	"
9	420	Light	"
10	Not taken	Recording gauge installed	
11	340	" 11 A. M.	"
12 Noon	380	Stronger	Natural
1	365	"	"
2	385	Strong	"
3	385	"	"
4	370	"	"
5	395	Light	Pump
6	415	No Flow	"
7	385	"	"
8	380	"	"
9	420	"	"
10	355	No Flow	"
11	380	Light	Natural
12 Night	350	"	"

TABLE NO. 2.
Page 3.

LOG OF SHRIVER #3 (CONT'D).

Nov. 7th, 1917.			
1 AM	345#	Stronger	Natural
2	340	Strong	"
3	375	"	"
4	380	"	"
5	345	Light	"
6	340	No Flow	Pump
7	345	"	"
8	360	"	"
9	390	"	"
10	375	"	"
11	375	"	"
12 Noon	345	Light	"
1	355	"	"
2	310	Stronger	"
3	365	Strong	"
4	340	"	"
5	300	"	"
6	315	"	"
7	315	Light	"
8	350	No Flow	"
9	350	"	"
10	345	"	"
11	375	Light	"
12 Night	330	"	"

TABLE NO. 2.
Page 4.

LOG OF SHRIVER #3 (CONT'D).

Nov. 8th, 1917.

1 AM	375#	Light	Natural
2	380	Stronger	"
3	400	Strong	"
4	435	"	"
5	410	"	"
6	325	No Flow	Pump
7	335	"	"
8	345	"	"
9	390	"	"
10	355	"	"
11	400	"	"
12 Noon	375	"	"
1 PM	375	Light	Natural
2	385	"	"
3	400	Stronger	"
4	425	Strong	"
5	430	"	"
6	415	"	"
7	345	"	"
8	350	No Flow	"
9	275	"	Pump
10	225	"	"
11	375	"	Natüral
12 Night	350	Stronger	Natural

TABLE NO. 2.
Page 5.

LOG OF SHRIVER #3 (CONT'D).

Nov. 9th, 1917.

1 AM	365#	Stronger			Natural
2	380	"			"
3	425	Strong			"
4	450	"			"
5	400	"			"
6	335	Light			"
7	370	No Flow			Pump
8	375	"			"
9	370	"	Started gauging tanks		"
10	345	"	hourly 1 P.M. 11-9-17		"
11	375	"			"
12 Noon	365	Light	Bbls. per Hr.		Natural
1 PM	360	"			"
2	380	Stronger	18.8)		"
3	400	"	23.7)		"
4	425	Strong	38.8)	154.1	"
5	430	"	36.5)		"
6	405	"	36.3)		"
7	315	Light	3.0		Pump
8	340	No Flow	2.5		"
9	370	"	0.9		"
10	330	"	1.3		"
11	370	"	0.6		"
12	340	"	0.6		"
		Total	163.0		

TABLE NO. 2.
Page 6.

LOG OF SHRIVER #3 (CONT'D).

Nov. 10th, 1917.			Bbls. per Hr.		
1 AM	375#	No Flow	1.3		Pump
2	350	"	0.6		"
3	360	Light	0.6		Natural
4	360	Stronger	10.0)		"
5	380	"	15.6)		"
6	400	Strong	15.0)		"
7	440	"	38.0)	183.3	"
8	420	"	54.5)		"
9	390	Lighter	30.0)		"
10	425	Light	20.2)		Pump
11	325	No Flow	2.0		"
12 Noon	370	"	0.6		"
1 PM	430	"	0.0		"
2	360	Light	1.9)		"
3	430	"	5.0)		"
4	400	Stronger	7.5)		Natural
5	395	"	11.9)		"
6	395	Strong	17.5)	166.6	"
7	405	"	22.8)		"
8	430	"	36.6)		"
9	430	"	50.0)		"
10	400	Light	15.3)		"
11	330	No Flow	4.4		Natural
12	350	"	0.6		Pump
	Total 24 Hours		361.9		

TABLE NO. 2.
Page 7.

LOG OF SHRIVER #3 (CONT'D).

Nov. 11th, 1917.			Bbls. per Hr.		
1 PM	360#	No Flow	1.3		Pump
2	400	"	0.3		"
3	360	"	0.9		"
4	330	Light	2.0		Natúral
5	340	Stronger	13.8)		Natural
6	360	"	20.0)		"
7	370	Strong	33.4)	167.7	"
8	400	"	44.4)		"
9	420	"	46.2)		"
10	370	No Flow	9.9)		Natural
11	300	"	0.0		"
12 Noon	265	"	1.3		"
1 PM	240	"	1.6		"
2	215	"	1.9		"
3	195	"	0.6		"
4	180	"	0.9		"
5	170	"	0.6		"
6	160	"	0.9		"
7	150	"	0.6		"
8	150	Light	2.8		"
9	150	"	8.1)		"
10	160	Stronger	13.1)		"
11	170	Strong	21.9)		"
12	180	"	18.8)		"
	Total	24 Hours	245.3		

Peak total 169.5

TABLE NO. 2.
Page 8.

LOG OF SHRIVER #3 (CONT'D).

Nov. 12th, 1917.			Bbls. per Hr.		
			Peak Total 169.5		
1 AM	200#	Strong	20.0)		Natural
2	230	"	25.2)		"
3	240	"	43.8)		"
4	220	Light	18.6)		"
5	175	No Flow	2.5		"
6	150	"	0.0		"
7	140	"	0.0		"
8	130	"	0.6		"
9	130	"	0.6		"
10	125	"	0.9		"
11	120	"	0.6		"
12 Noon	120	"	0.3		"
1 PM	120	"	0.6		"
2	110	Light	2.5		"
3	140	"	12.8)		"
4	150	Stronger	14.7)		"
5	165	Heavy	22.8)		"
6	185	"	24.7)	205.3	"
7	200	"	44.6)		"
8	210	"	60.4)		"
9	205	Light	25.3)		Pump
10	310	No Flow	2.5		"
11	335	"	0.6		"
12 Night	185	"	0.9		Natural
		Total 24 Hours	325.5		

TABLE NO. 2.
Page 9.

LOG OF SHRIVER #3 (CONT'D).

Nov. 13th, 1917.			Bbls. per Hr.		
1 AM	180#	No Flow	0.6		Natural
2	170	"	0.3		"
3	160	"	0.3		"
4	150	"	1.3		"
5	150	"	0.9		"
6	140	"	0.3		"
7	135	"	0.6		"
8	135	Light	1.3		"
9	140	Stronger	11.9)		"
10	160	"	14.4)		"
11	170	Strong	15.6)		"
12 Noon	200	"	26.0)	208.2	"
1 PM	215	"	32.8)		"
2	240	"	42.8)		"
3	250	"	64.7)		"
4	230	Light	0.0		"
5	190	No Flow	0.9		"
6	165	"	0.3		"
7	465	"	0.3		Pump
8	450	"	0.6		"
9	405	"	0.6		"
10	375	"	0.6		"
11	350	"	1.3		"
12 Night	300	"	1.3		"

Total 24 Hours 219.7

TABLE NO. 2.
Page 10.

LOG OF SHRIVER #3 (CONT'D).

Nov. 14th, 1917.			Bbls. per Hr.	
1 AM	305#	No Flow	5.0	Pump
2	310	Light	10.9	"
3	350	"	15.6	"
4	315	Stronger	24.4	"
5	410	Strong	Flow Tank	Natural
6	450	"	over flowing	"
7	445	"	"	"
8	402	Light	"	"
9				
10	No readings taken between 9 AM and 8 PM on			
11	account of connection gang running 1" air line into			
12 Noon	hole. Pressure taken off mud at 9 AM. When pres-			
1 PM	sure was released, a little mud flowed out. When			
2	clamps were taken off, tubing rose about 3" and mud			
3	dropped several feet in tubing.			
4				
5				
6				
7	Depth of top of			
8	Mud below tubing			
9	3' - 5-3/4"	No Flow		Tubing Open
10	4' - 1"	"	1.3	Natural
11	4' - 9-1/4"	"	1.3	"
12 Night	5' - 4-5/8"	"	0.3	"

TABLE NO. 2.
Page 11.

LOG OF SHRIVER #3 (CONT'D).

Nov. 15th, 1917.

	Depth of top of Mud below tubing		Bbls. per Hr.		
1 AM	5' - 9"	No Flow	0.3		Tubing Open
2	6' - 5/8"	"	1.9		Natural
3	6' - 4"	"	0.6		"
4	6' - 4 7/8"	Light	5.3)		"
5	6' - 4 1/2"	"	12.2)		"
6	6' - 7 1/4"	Stronger	15.3)		"
7	5' - 1"	Strong	29.1)	152.9	"
8	4' - 3"	"	45.0)		"
9	3' - 6 1/4"	"	40.0)		"
10	3' - 4 5/8"	Light	6.0)		"
11	4' - 5 1/2"	No Flow	1.6		"
12 Noon	5" - 3 1/4"	"	0.3		"
1 PM	(Not taken)	"	)		"
2	"	"	) 5.9		"
3	6' - 11"	"	)		"
4	7' - 3/4"	"	0.6		"
5	7' - 3"	"	1.3		"
6	7' - 6"	"	0.6		"
7	7' - 8 1/4"	"	0.6		"
8	7' - 10 3/4"	"	0.6		"
9	8' - 0"	"	0.9		"
10	8' - 1 5/8"	"	1.6		"
11	8' - 2"	Light	3.8		"
12 Night	7' - 10 3/8"	"	8.7)		"

Total for 24 Hours 182.2

Peak total 190.4

TABLE NO. 2.
Page 12.

LOG OF SHRIVER #3 (CONT'D).

Nov. 16th, 1917.	Depth of top of Mud below tubing		Bbls. per Hr. Peak total 190.4		
1 AM	8' - 2 1/4"	Light	15.6)		Tubing Open
2	6' - 4 3/4"	Stronger	20.9)		Natural
3	5' - 6 1/4"	Strong	25.0)		"
4	4' - 10 1/4"	"	38.5)		"
5	4' - 7 3/4"	"	34.7)		"
6	4' - 5 3/4"	"	43.0)		"
7	4' - 11 1/4"	No Flow	4.0)		"
8	4' - 5 3/2"	"	0.3		"
9	6' - 6 3/4"	"	0.9		"
10	7' - 1"	"	0.9		"
11	7' - 6 3/4"	"	0.3		"
12 Noon	________	"	0.6		Mud Pressure Put on at Noon
1 PM	460#	"	0.9		Pump
2	420	"	1.3		"
3	438	"	0.9		"
4	540	Light	5.0)		"
5	585	Stronger	6.6)		Natural
6	600	"	22.5)		"
7	630	Strong	34.1)	152.0	"
8	645	"	47.0)		"
9	605	Light	28.0)		"
10	500	No Flow	6.3)		Pump
11	480	"	2.5		"
12 Night	500	"	0.3		"
		Total for 24 hrs.	340.1		

TABLE NO. 2.
Page 13.

LOG OF SHRIVER #3 (CONT'D).

Nov. 17th, 1917.			Bbls. per Hr.		
1 AM	505#	No Flow	0.3		Pump
2	515	"	0.3		"
3	535	"	0.6		"
4	540	"	3.8)		"
5	575	Light	13.5)		Natural
6	600	"	17.5)		"
7	600	Strong	15.0)	127.0	"
8	600	"	19.0)		Pump
9	610	"	38.9)		"
10	545	No Flow	19.3)		"
11	475	"	0.3		"
12 Noon	500	"	0.3		"
1 PM	510	"	0.6		"
2	530	"	0.3		"
3	510	"	0.3		"
4	450	"	0.6		"
5	560	Light	5.9)		"
6	600	Stronger	19.1)		Natural
7	600	"	21.9)		"
8	620	Strong	27.2)	127.0	"
9	620	"	32.0)		"
10	560	No Flow	20.9)		"
11	480	"	1.6		"
12 Night	500	"	0.3		Pump

Total for 24 Hrs. 259.5

TABLE NO. 2.
Page 14.

LOG OF SHRIVER #3 (CONT'D).

Nov. 18th, 1917.			Bbls. per Hr.		
1 AM	500#	No Flow	0.3		Pump
2	515	"	0.6		"
3	530	"	1.3		"
4	540	"	0.6		"
5	540	"	0.6		"
6	540	"	0.6		"
7	500	"	0.3		"
8	550	Light	2.5)		"
9	545	No Flow	3.6)		"
10	550	"	.5)		"
11	580	Light	9.8)		Natural
12 Noon	620	Strong	17.5)	184.8	"
1 PM	650	"	28.8)		"
2	670	"	36.9)		"
3	685	"	48.9)		Pump
4	710	Light	26.6)		"
5	590	No Flow	17.7)		"
6	510	"	0.9		"
7	600	"	0.6		"
8	500	"	0.3		"
9	510	"	1.6		"
10	520	"	1.6		"
11	510	"	0.3		"
12	520	"	0.3		"
		Total	204.7		

TABLE NO. 2.
Page 15.

LOG OF SHRIVER #3 (CONT'D).

Nov. 19th, 1917.			Bbls. per hr.		
1 AM	530#	No Flow	1.9		Pump
2	575	"	7.5)		"
3	605	Stronger	14.1)		Natural
4	615	Strong	27.2)		"
5	649	"	23.8)	171.2	"
6	640	"	34.1)		"
7	640	"	37.)		"
8	640	No Flow	26.7)		"
9	650	"	0.3		"
10	380	"	0.6		Pump not working
11	650	"	1.3		Pump
12 Noon	610	"	0.9		"
1 PM	660	"	0.9		"
2	690	"	2.5)		"
3	680	Light	3.1)		"
4	770	"	12.5)		"
5	790	Strong	24.0)	152.0	"
6	800	"	17.5)		Pressure on mud re-
7	800	"	29.5)		maining stationary
8	800	"	44.7)		without pumping
9	750	No Flow	23.8)		Pump
10	750	"	0.3		"
11	610	"	0.3		"
12 Night	530	"	0.9		"

Total for 24 Hrs. 336.2

TABLE NO. 2.
Page 16.

LOG OF SHRIVER #3 (CONT'D).

Nov. 20, 1917.			Bbls. per Hr.		
1 AM	570#	No Flow	0.9		Pump
2	530	"	0.9		"
3	545	"	0.6		"
4	540	"	1.0		"
5	550	"	0.6		"
6	560	Light	5.0		"
7	570	"	13.4)		"
8	595	Strong	19.0)		Natural
9	625	"	27.2)		"
10	650	"	32.9)	154.1	Pump
11	850	"	43.8)		"
12 Noon	830	No Flow	12.8)		Natural
1 PM	805	"	66.8		"
2	810	"	5.0		"
3	900	Strong	65.6		"
4	900	"	32.9		"
5	700	Light	44.5		Pump
6	700	No Flow	0.6		"
7	680	Strong	20.0		"
8	590	"	49.7		"
9	720	Light	60.6		"
10	750	Intermittent	22.2		
11	740	"	20.3		
12	775	Very Strong	21.3		
		Total	546.6		

TABLE NO. 2.
Page 17.

LOG OF SHRIVER #3 (CONT'D).

Nov. 21st, 1917.			Bbls. per Hr.	
1 AM	850#	Strong	36.9	Pump
2	775	"	28.7	"
3	770	Light	23.7	"
4	775	No Flow	13.7	"
5	840	Stronger	30.3	"
6	810	Strong	38.1	"
7	805	Light	10.0	"
8	715	No Flow	5.2	"
9	780	Light	20.9	"
10	825	Stronger	30.9	"
11	855	No Flow	54.9	"
12 Noon	730	"	2.8	"
1 PM	720	"	0.3	"
2	730	"	0.3	Pump Broke
3	670	"	0	Natural
4	570	"	0.3	"
5	500	"	0	"
6	440	"	0	"
7	400	"	0	"
8	360	"	0	"
9	330	"	0	"
10	300	"	0	"
11	260	"	0	"
12 Night	240	"	0	"
	Total 24 Hours		297.0	

TABLE NO. 2.
Page 18.

LOG OF SHRIVER #3 (CONT'D).

Nov. 22nd, 1917.			Bbls. per Hr.	
1 AM	225#	No Flow	0	No Pump
2	200	"	0	"
3	190	"	0	"
4	180	"	0	"
5	175	"	0	"
6	165	"	0	"
7	155	"	0	"
8	150	"	0	"
9	145	"	0	"
10	140	"	0	"
11	135	"	0	"
12 Noon	125	"	0	"
1 PM	120	"	0	"
2	120	"	0	"
3	114	"	0	"
4	110	"	0	"
5	110	"	0	"
6	105	"	0	"
7	100	"	0	"
8	95	"	0	"
9	90	"	0	"
10	90	"	0	"
11	90	"	0	"
12	90	"	0	"
			0	

TABLE NO. 3.
Page 1.

"PARALLEL" TIDE.

DATE	OLD POINT COMPORT VIRGINIA			SAN FRANCISCO CALIF.					EL DORADO KANSAS.	
	A	B		A		B			A	B
NOV.1917	AM	PM	AM	PM	AM	PM	AM	PM	PM	AM
3	11.42					1.27	3.29		12.35	
4		12.35	0.10			2.22	4.28		1.29	2.19
5		1.32	1.08			3.33	5.22		2.32	3.15
6		2.30	2.09			4.50	6.10		3.40	4.10
7		3.28	3.11			6.06	6.50		4.47	5.00
8		4.22	4.07			7.15	7.26		5.49	5.36
9		5.11	4.58			8.17	7.58		6.29	6.28
10		5.56	5.42			9.13	8.29		7.24	7.10
11		6.38	6.23			10.06	8.58		8.07	7.41
12		7.18	7.00			10.56	9.23		8.52	8.12
13		7.56	7.36			11.46	9.50		9.36	8.43
14		8.33	8.12				10.14			9.13
15		9.09	8.47		0.35		10.41		10.52	9.29
16		9.50	9.25		1.24		11.11		11.12	10.18
									AM	
17		10.33	10.06		2.17		11.47		0.10	10.57
18		11.24	10.52		3.09			12.30	1.02	11.41
										PM
19			11.43		4.01			1.22		12.33
20	0.30			12.40	4.49			2.32	2.35	1.21
21	1.25			1.44	5.33			4.03	3.29	2.54
22	2.34			2.53	6.14			5.43	4.09	4.18
23	3.42			4.00	6.55			7.12	5.04	5.21
24	4.43			5.04	7.34			8.30		
25	5.40			6.01	8.14			9.39		

TABLE NO. 4.
Page 1.

"GREAT CIRCLE" TIDE.

DATE	SANDY HOOK, DEL.				SAN DIEGO, CALIF.			EL DORADO, KANS.			
	A		B			B		A		B	
NOV.1917	AM	PM	AM	PM	AM	AM	PM	AM	PM	AM	PM
3	10.20			10.52	0.28	11.06			11.40	10.43	
4	11.09			11.49	1.41	11.58		0.45		11.34	
5	12.00				3.09		1.07				12.38
6		12.54	0.42		4.16		2.33	2.12			1.44
7		1.50	1.38		4.57		3.57	3.03			2.54
8		2.45	2.32		5.28		5.07	4.15			4.11
9		3,38	3.23		5.55		6.03	4.40			4.51
10		4.24	4.10		6.22		6.52	5.16			5.38
11		5.10	4.55		6.49		7.36	6.02			6.15
12		5.59	5.37		7.15		8.18	6.26			7.09
13		6.40	6.18		7.43		8.57	7.01			7.49
14		7.22	6.56		8.11		9.37	7.34			8.30
15		8.04	7.37		8.41		10.20	8.09			9.13
16		8.48	8.17		9.14		11.08	8.46			9.58
17		9.33	8.59		9.51			9.25			
18		10.25	9.45		10.24	0.02		10.05			11.14
19		11.20	10.35		11.27	1.05		11.01		0.13	
					PM						
20			11.32		12.34	2.10			12.03		
21	0.21			12.34	1.59	3.12			1.27	1.47	
22	1.24			1.38	3.32	4.05			2.35	2.44	
23	2.25			2.42	4.56	4.51			3.49	3.38	
24	3.22			3.45	6.09	5.32			4.57	4.27	

TABLE NO. 5.
Page 1

TIME OF MOON RISING
AND MOON SETTING FOR WASHINGTON D. C.
75° W. Time MERIDIAN.

Date Nov. 1917	Rise	Set
3	8:47 P.M.	11:07 A.M.
4	9:49 "	11:49 "
5	10:49 "	12:23 A.M.
6	11:49 "	12:51
7		1:20
8	0:47 A.M.	1:44
9	1:45	2:08
10	2:42	2:32
11	3:41	2:58
12	4:42	3:26
13	5:44	4:00
14	6:47	4:38
15	7:49	5:25
16	8:49	6:19
17	9:44	7:20
18	10:33	8:27
19	11:15	9:36
20	11:51	10:37
21	12:24 P.M.	11:57
22	12:54	
23	1:23	1:07 A.M.
24	1:54	2:17
25	2:27	3:29

TABLE NO. 6.
Page 1.

MEAN & STANDARD TIME OF
MOON'S MERIDIAN PASSAGE AT ELDORADO, KANSAS.
(From Eichelberger)

	MEAN TIME			STANDARD TIME (CENTRAL)		
1917	Hours	Minutes		Hours	Minutes	
Oct. 31	12	34.4	A.M.	1	1.8	A.M.
Nov. 1	1	32.3	"	1	59.7	"
2	2	29.8	"	2	57.2	"
3	3	25.0	"	3	52.4	"
4	4	17.1	"	4	44.5	"
5	5	5.7	"	5	33.1	"
6	5	51.0	"	6	18.4	"
7	6	33.8	"	7	1.2	"
8	7	14.9	"	7	42.3	"
9	7	55.4	"	8	22.8	"
10	8	36.2	"	9	3.6	"
11	9	18.2	"	9	45.6	"
12	10	2.4	"	10	29.8	"
13	10	49.6	"	11	17.0	"
14	11	40.1	"	12	7.5	P.M.
15	12	33.8	P.M.	1	1.2	"
16	1	29.8	"	1	57.2	"
17	2	26.9	"	2	54.3	"
18	3	23.2	"	3	50.6	"
19	4	17.9	"	4	45.3	"
20	5	10.5	"	5	37.9	"
21	6	1.3	"	6	28.7	"
22	6	51.0	"	7	18.4	"
23	7	40.8	"	8	8.2	"
24	8	31.7	"	8	59.1	"
25	9	24.4	"	9	51.8	"
26	10	19.4	"	10	46.8	"
27	11	19.4	"	11	43.8	"
28	--	----		--	----	
29	12	14.0	A.M.	12	41.4	A.M.
30	1	10.8	"	1	38.2	"
Dec. 1	2	5.2	"	2	32.6	"

TABLE NO. 7.
Page 1.

MEAN LOCAL TIME
38° N. Latitude
RISING AND SETTING OF THE SUN.

Date Nov. 1917	Rise	Set
2	6:24	5:03
3	6:15	5:02
4	6:26	5:01
5	6:27	5:00
6	6:28	4:59
7	6:29	4:59
8	6:30	4:58
9	6:31	4:57
10	6:32	4:56
11	6:33	4:55
12	6:34	4:55
13	6:35	4:54
14	6:36	4:54
15	6:37	4:53
16	6:38	4:52
17	6:39	4:52
18	6:40	4:51
19	6:41	4:51
20	6:42	4:50
21	6:43	4:49
22	6:44	4:49
23	6:45	4:48
24	6:46	4:48
25	6:47	4:47

TABLE NO. 8.
Page 1.

WEIGHT OF STRATA.

Nature of Strata	Feet Thickness	Pounds Weight per Foot	Pounds Weight of Strata
Lime and Earth	120	125	15,000
Red Rock	6	140	840
Lime Shell	6	150	900
Slate	8	170	1,360
Red Rock	10	140	1,400
Lime	5	150	750
Slate	40	170	6,800
Slate and Lime	45	160	7,200
Lime	65	150	9,750
Slate	25	170	4,250
Lime	12	150	1,800
Slate	78	170	13,260
Lime	5	150	750
Red Rock	20	140	2,800
Slate	115	170	19,550
Lime	12	150	1,800
Slate	68	170	11,560
Lime	20	150	3,000
Slate	6	170	1,020
Lime	6	150	900
Slate	53	170	9,010
Slate & Shells	85	160	13,600
Lime	25	150	3,750
Slate	10	170	1,700
Slate and Shells	25	160	4,000
Slate	100	170	17,000
Lime	60	150	9,000
Slate	20	170	3,400
Lime	100	150	15,000
Slate	10	170	1,700
Lime	90	150	13,500
Slate	5	170	850
Lime	55	150	8,250
Slate	25	170	4,250
Lime	35	150	5,250
Slate	102	170	17,340
Lime	8	150	1,200
Slate	30	170	5,100
Lime	220	150	33,000
Slate	125	170	21,250

TABLE NO. 8.
Page 2.

WEIGHT OF STRATA (CONT'D).

Nature of Strata	Feet Thickness	Pounds Weight per Foot	Pounds Weight of Strata
Lime	65	150	9,750
Water Sand	20	140	2,800
Lime	56	150	8,400
Slate	114	170	19,380
Slate and Shells	75	160	12,000
Slate	58	170	9,860
Stapleton Sand	35	140	4,900
	Total weight		359,930
	Lbs. per sq. in.		2,500